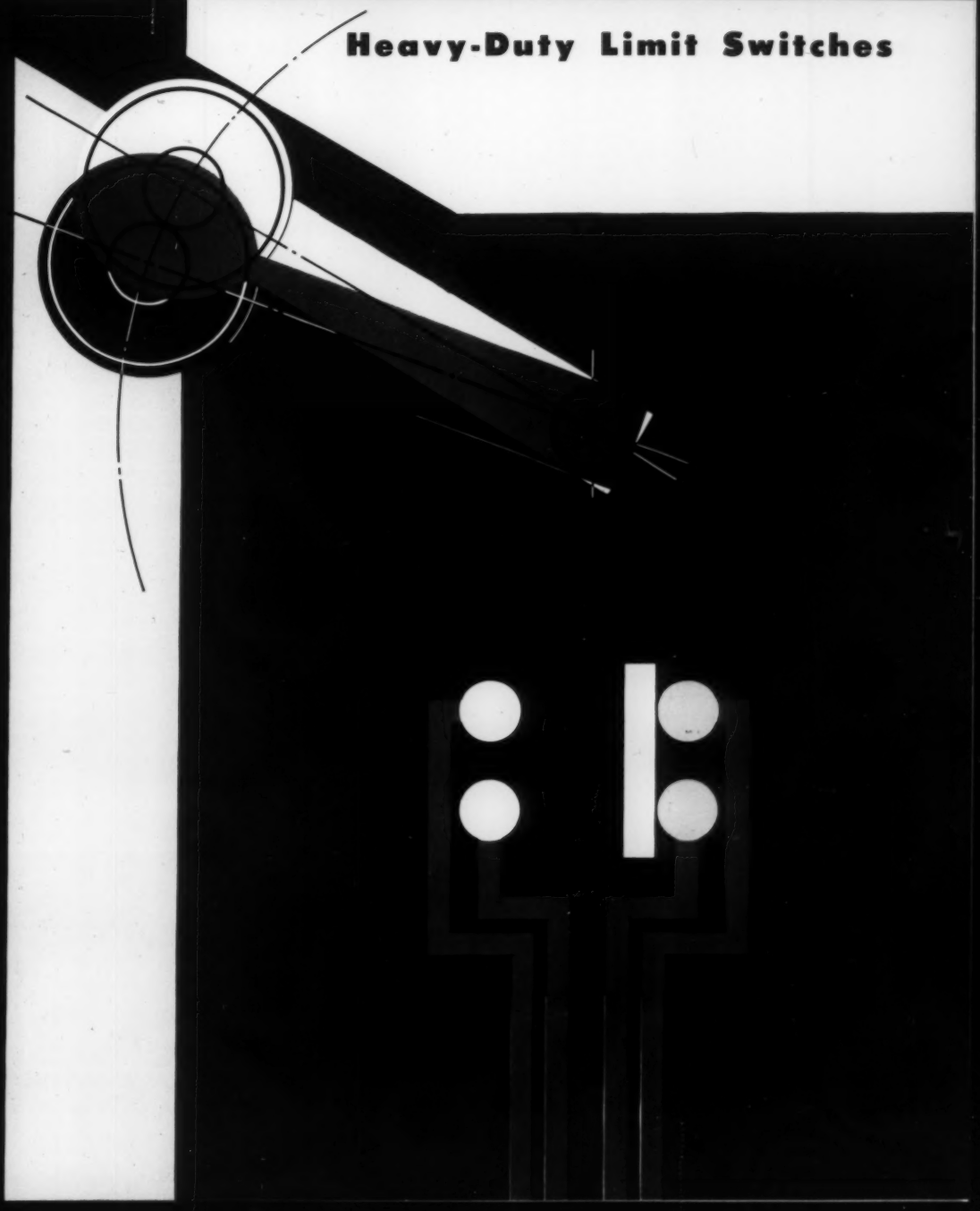
MACHINE

DESIGN

ATION — BIWEEKLY

Heavy-Duty Limit Switches



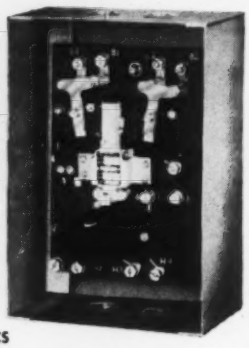
ASCO time delay relay handles motor loads directly!

field adjustable from ½ to 6 seconds . . . for all voltages

A rugged power type relay, with power relay electrical characteristics (see table), enables this ASCO Time Delay Unit to handle motor loads directly. Alternate designs require two devices: a time delay relay and a contactor. ASCO provides both in one reliable unit!

A simple screwdriver adjustment permits any time delay on dropout from ½ to 6 seconds . . . and the ASCO designed adapter makes the device suitable for 240, 480, and 600 volts, 60 cycles (120 volts without the adapter). The unit is also available for other frequencies and for D-C.

Multiple contacts are available in various combinations permitting the use of one relay, where with other time delay devices additional relaying would be required.



Time Delay Relay in NEMA 1A cabinet—note adapter mounted beneath the relay. The three units, cabinet, time delay relay and adapter, form a time delay combination for any standard A-C voltage.

ASCO Time Delay Relays can be furnished with fixed or adjustable time delays . . . for time delay when the circuit is energized or de-energized . . . for A-C operation at frequencies from 25 to 2000 cycles, and for D-C.

ELECTRICAL CHARACTERISTICS

Maximum Current on Make.....300 Amps.
Continuous Current
Carrying Capacity..... 25 Amps.

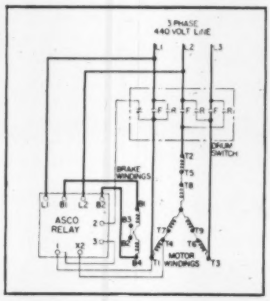
A-C Voltage	Break Currents at Maximum Operations per Minute of:		
	1	10	20
120	150	70	50
240	115	60	45
480	65	45	30
600	50	35	25

Based on approximately 50% "on time". Where percent "on time" is less than 50%, higher ratings can be applied.

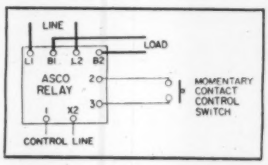
OTHER FEATURES

• Double Break Silver Contacts with Wiping Action • Clapper Type Magnet with Oilite Bearings at Pivot • Vacuum impregnated coil • Low Loss Silicon Steel Magnet Frame • Telephone Quality Capacitor Conforming to Spec. No. JAN-C-62, manufactured and tested to ASCO specifications • Selenium Rectifiers used Conservatively • Creepage Distance Well in Excess of NEMA and Underwriters' Laboratory Requirements for 600 Volts.

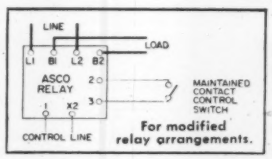
APPLICATIONS



For Brake Winding Motors — Each time the motor controller is operated to the "motor stop" position, this relay closes, energizing the brake winding to stop the motor. The relay disconnects the brake winding after a pre-set interval.



For "Single Pulse" Time Delay— Each momentary pushbutton closing causes the relay to close, connecting the line to the controlled equipment. The relay automatically disconnects the circuit ½ to 6 seconds later, depending upon the setting.



For "Repeated Cycling" Time Delay — Repeated relay closings and dropouts at ½ - 6 second intervals are provided with the external contact closed.

In Automatic Controls — instantaneous acting control relays quite often introduce complications of instability, variations in cycling, accelerated contact erosion, hunting of associated relays and unnecessary shutdowns due to transient conditions. These conditions can be overcome with ASCO Time Delay Relays.

Time Delay Relays are only part of the complete line of Relays offered by ASCO. Catalog 57-S4 lists:

- **MAGNETICALLY HELD RELAYS**
  AC or DC . . . Normally Open . . . Normally Closed . . . Double Throw
- **MECHANICALLY HELD RELAYS**
  AC or DC . . . All Pole Combinations
- **SPECIALIZED RELAYS, INCLUDING:**
  . . . Reverse Current
  . . . Close Differential
  . . . Current Type Welding
  . . . Electronic
  . . . Modified Arrangements

Write for your copy of "Relays by ASCO"— Catalog 57-S4.

Automatic Switch Co.
54-A Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO®

Circle 401 on Page 19

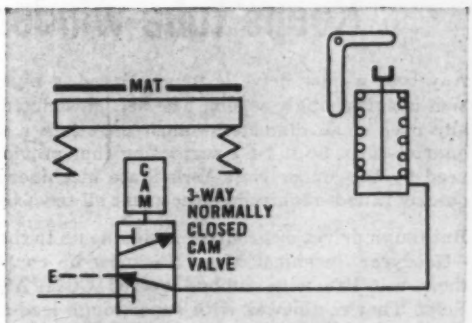
What? Air Won't Let Him Get Too Fat!

We admit we are not serious, but . . .

In a previous moment of strength he has set the controls—now, if he weighs over 200 pounds when he steps on the mat in front of the refrigerator, the door just won't open. But while he is under 200 pounds, no trouble. Now, it's highly unlikely that the refrigerator folks will be mobbed by eager buyers for such a diet-master model, but we have jumped on it as a good chance to show how a cam valve can say "yes" or "no."

Ross Cam Valves can "think" for your circuits, too

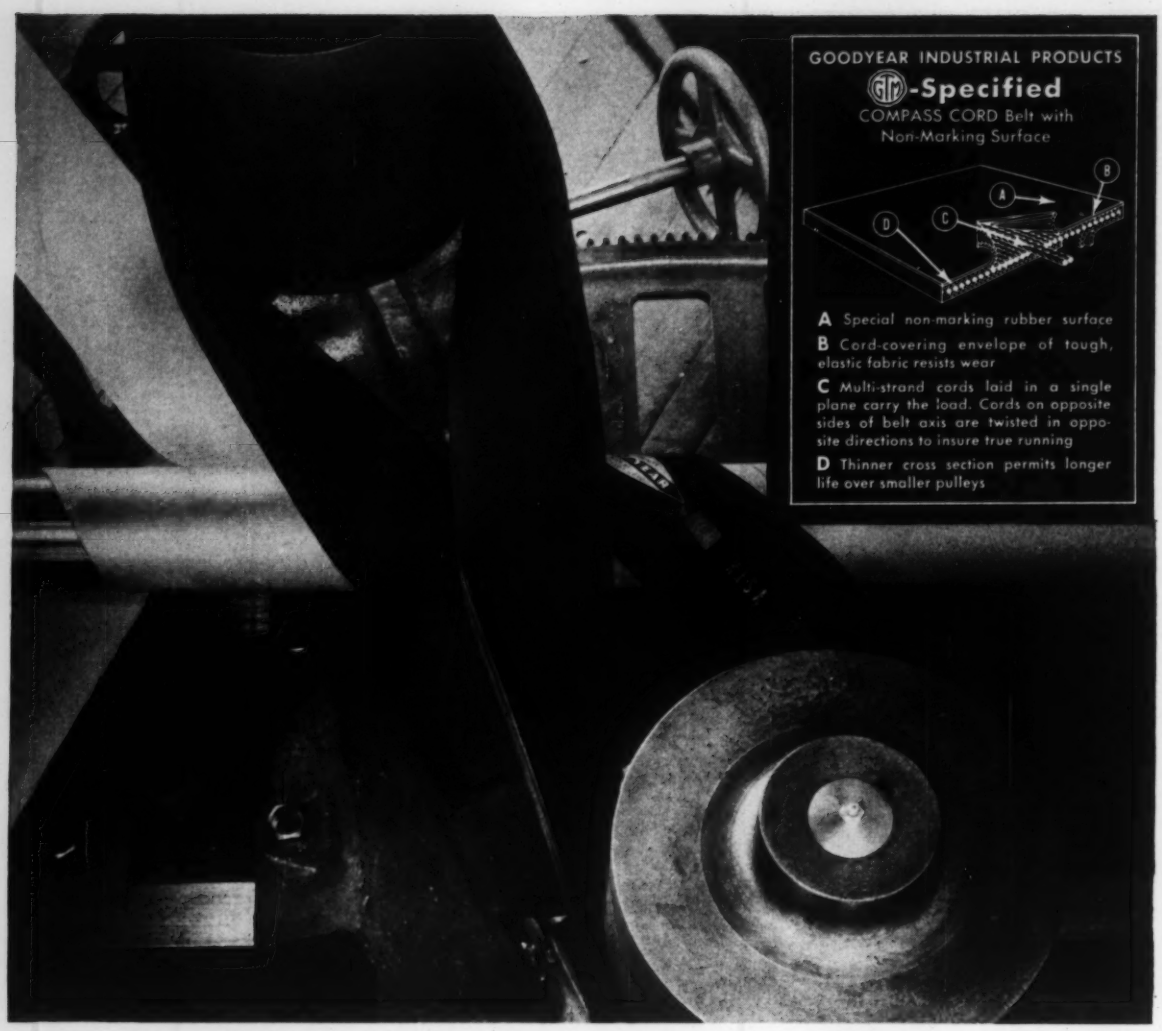
Cam valves are the key to air automation. They can act on almost any mechanical signal to set off . . . or restrict . . . another operation. Then still another cam valve can interlock that circuit with yet further operations and so on until any number of operations can be sequencing one another. Are you realizing the full possibilities from cam valves? The Ross line includes so many models, we invite you to call your Ross representative or write us.



SEQUENCE OF OPERATION
Sufficient weight on mat depresses cam, operating valve and moving cylinder to point where it restrains door handle from opening.

Ross OPERATING VALVE CO. **109 E. Golden Gate Ave. • Detroit 3, Michigan**

Circle 404 on Page 19


GOODYEAR INDUSTRIAL PRODUCTS
G.T.M.-Specified
COMPASS CORD Belt with
Non-Marking Surface
A
B
C
D
A Special non-marking rubber surface
B Cord-covering envelope of tough, elastic fabric resists wear
C Multi-strand cords laid in a single plane carry the load. Cords on opposite sides of belt axis are twisted in opposite directions to insure true running
D Thinner cross section permits longer life over smaller pulleys

Keeps tube-winder wound up 3 times as long!

Any tube-winder drive is tough. Speed is high. Abrasion is surprisingly severe. The belt must flex continually over small diameters—must negotiate a twisting quarter-turn. So it isn't surprising that previous belts used by this upper New York State machinery maker quickly failed—required replacement all too soon.

But tough drives are routine assignments to the G.T.M.—Goodyear Technical Man. He knew he could better their belt life with rubber-covered COMPASS Cord Belts. They're sinewed with super-tough load-carrying cords for maximum resistance to stretch and abrasion—have the thin cross section which facilitates small-pulley operation. *Result: The G.T.M.'s belts are outlasting their predecessors 2- and 3-1—often better than that.*

What about your belting problems? The first step toward a moneysaving solution is a call to the G.T.M. Contact him through your Goodyear Distributor—or by writing Goodyear, Industrial Products Division, Akron 16, Ohio.

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

COMPASS CORD BELT BY

GOODYEAR

60th ANNIVERSARY

THE GREATEST NAME IN RUBBER

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Circle 405 on Page 19

Front Cover: The motion needed to trip a limit switch is depicted graphically by artist George Farnsworth to highlight the article by Robert Denison on Page 104.

February 5, 1959

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NEWS REPORT—Breakthrough by the Russians: A radical heat-pressure process for boosting the wear resistance of machined-steel parts.

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Photographed underwater at Florida's Silver Springs

Skin-diving demonstration shows what we mean when we say Sealtite flexible conduit is liquid-tight

The new Immersible Motor recently introduced by The Louis Allis Company demonstrated, at the bottom of Florida's famous Silver Springs, its ability to operate completely submerged.

Skin-diving right along with the motor was Sealtite Type E.F. flexible conduit, guarding the electric lines to the power source on dry land. The demonstration dramatically showed that Sealtite remains liquid-tight under unusual conditions.

The tougher jobs that Sealtite is designed for are less dramatic. Standing up under hot sun, rain, sleet, ice, through the seasons is harder. So is shrugging off oils, grease, corrosive fumes, chemicals, salt spray. Yet in mills, mines, process industries, Sealtite quietly keeps equipment operating dependably under conditions that would quickly knock out ordinary conduit.

Want to know more? Electrical Wholesalers stock Types U.A. and E.F.* Sealtite in easy-to-handle cartons or on reels in gray and black. Be certain you ask for and get the quality conduit marked "Sealtite" on the cover. Buy it in long lengths and cut it on the job without waste. Your wholesaler also stocks liquid-tight connectors. Free Booklet S-541 gives you full information on Sealtite. For your copy, write: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. In Canada, Sealtite is approved by Canadian Standards Association, and sold by Anaconda American Brass Ltd., New Toronto, Ontario.

*Patent Applied For 58186

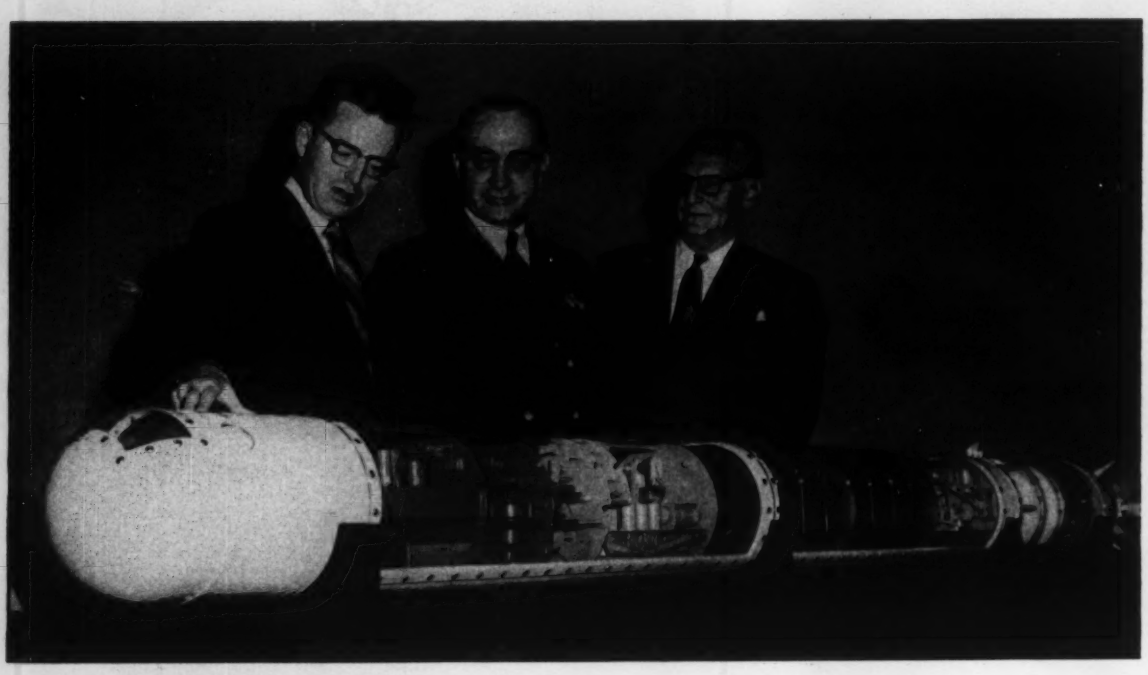
CUTAWAY SECTION of Type U.A. Sealtite shows tough polyvinyl jacket extruded over flexible metal core. Copper conductor wound spirally inside conduit gives positive ground.

Insist on the conduit marked **SEALTITE®**

FLEXIBLE, LIQUID-TIGHT CONDUIT

an **ANACONDA®** *product*

Circle 406 on Page 19



Friendly Underwater Enemy

Highly sophisticated submarine simulator, newest addition to the fleet, will give antisub commanders realistic competition during underseas warfare training. Programmed before launching to follow a series of expert tactical maneuvers, the salty drone even transmits propeller and machinery noises identical to those of an actual submarine taking evasive action. It also picks up and amplifies search signals from antisubmarine vessels to simulate full-size Sonar contact. Developed by Clevite Corp., Cleveland, the decoy is only 11 ft long, 1 ft in diameter, and can be launched from shipboard, submarine, or helicopter. After a 6-hr mission, it surfaces and spouts smoke for recovery.

Aircraft with Missile Guidance Flies by Film and Radar

Pinpoint Navigator Feels Course over Filmed Terrain

AKRON—Guided by radar and a never-before-used synthetic film of the terrain, a large twin-engine aircraft has successfully flown exactly prescribed courses covering hundreds of miles in an unusual demonstration of self-contained electronic guidance.

Scene of the recent demonstration was West Germany. The airplane was an Air Force C-47, the film came from a library maintained by the Air Force, and the guidance was a standard ATRAN unit built by Goodyear Aircraft Corp. for the TM-76A Mace weapon system.

The successful demonstration marked the first time a film had been taken "off the shelf" for use in a guidance-system test.

With a number of courses already "plotted" on film for the Air Force library, the demonstration could have taken place almost anywhere in the world.

The ATRAN system is unique in that it controls a missile during flight without ground or air control of any kind subsequent to launching. Once airborne, an ATRAN-equipped missile or aircraft can ascend to clear a mountain range, descend to a few hundred feet over a coastal plain, or fly a winding course for hundreds of miles—completely independent of human control at all times.

Since the programmed information needed for guidance is stored on film inside the aircraft, the ultimate range of the system is limited only by the range of the carrier. The system could control the flight of a supersonic aircraft from New York to Los Angeles, and upon arrival in the terminal area, direct the vehicle to a preselected point with uncanny accuracy.

Since topographical maps and cultural data exist for much of the world, synthetic film can be quickly made, enabling a missile or aircraft to be electronically guided almost anywhere.

Fluid Power news

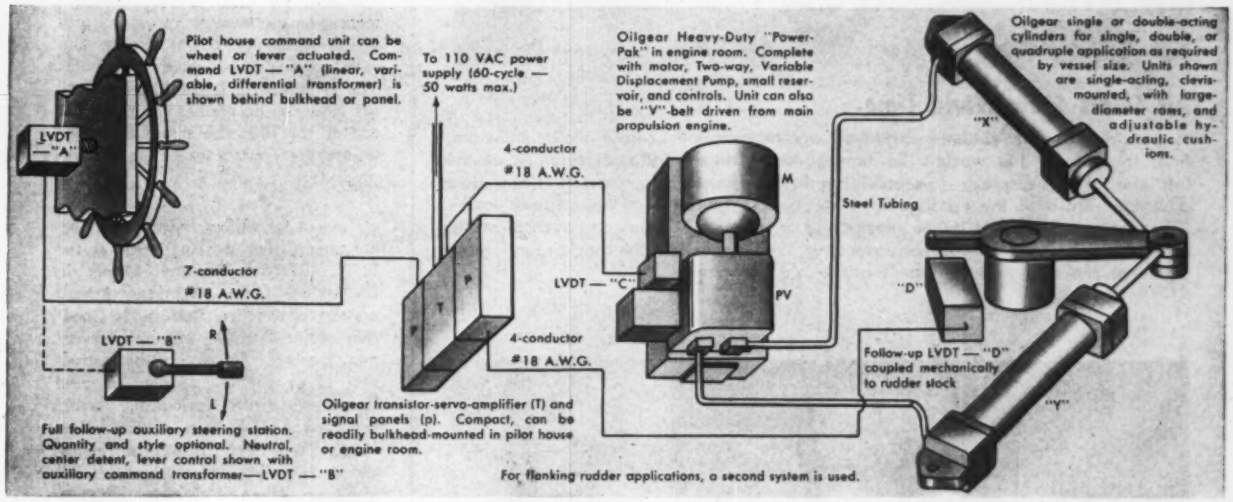
REPORT No. 11.702 NEW MARINE STEERING CONCEPT

From Oilgear Application-Engineering Files

HOW OILGEAR APPLICATION-ENGINEERING AIDED CREATION OF MODERN MARINE STEERING GEAR

CUSTOMER: *A long-established Marine Engineering Company (name on request)*

DATA: This company's technical staff concluded that marine steering gear could be modernized instead of merely being made larger and heavier. A design program to incorporate new electric and hydraulic developments had the following basic objectives. 1: Extreme flexibility for normal application on all vessels requiring power steering. 2: New economy in system weight, size, and installed cost. 3: Simplicity, accuracy, reliability. 4: Full follow-up pilot house and auxiliary station control of rudder movement, speed, position. 5: Eliminate make-and-break, or sliding electrical contacts, relays, vacuum tubes, solenoid valves, heavy shafting, gears, racks, and linkage in the control system. Smooth, positively indexed, rate responsive, stepless rudder movement control that is noise, shock, vibration, and pulsation-free. 7: Compatible with gyro-compass, automatic steering.


Pilot house command unit can be wheel or lever actuated. Command LVDT — "A" (linear, variable, differential transformer) is shown behind bulkhead or panel.
LVDT — "A"
To 110 VAC power supply (60-cycle — 50 watts max.)
Oilgear Heavy-Duty "Power-Pak" in engine room. Complete with motor, Two-way, Variable Displacement Pump, small reservoir, and controls. Unit can also be "V"-belt driven from main propulsion engine.
Oilgear single or double-acting cylinders for single, double, or quadruple application as required by vessel size. Units shown are single-acting, clevis-mounted, with large-diameter rams, and adjustable hydraulic cushions.
4-conductor #18 A.W.G.
M
Steel Tubing
"X"
7-conductor #18 A.W.G.
LVDT — "C"
PV
"D"
LVDT — "B"
R
L
4-conductor #18 A.W.G.
Follow-up LVDT — "D" coupled mechanically to rudder stock
"Y"
Full follow-up auxiliary steering station. Quantity and style optional. Neutral, center detent, lever control shown with auxiliary command transformer—LVDT — "B"
Oilgear transistor-servo-amplifier (T) and signal panels (p). Compact, can be readily bulkhead-mounted in pilot house or engine room.
For flanking rudder applications, a second system is used.

SOLUTION: Above schematic symbolizes an Oilgear Fluid Powered, electrically controlled, marine steering system utilizing the newest electric-hydraulic developments. *Actual installations using this new Oilgear "electro-feedback-hydraulic-servo-control system" have exceeded ALL of the customer's original engineering objectives* . . . proof of Oilgear's cooperation and teamwork to help solve design engineer's problems. Oilgear Heavy-Duty "Power-Paks" are complete, ready-to-install power units in sizes and types to meet every marine need. No auxiliary valves, pumps, controls, reservoirs, or "plumbing" are required. Oilgear "Custom-Quality" single and double-acting cylinders can furnish the "muscle" to control any type vessel. Oilgear ServoControl Division's rugged, compact transistor-servo-amplifier and control system is further proof of Oilgear progressive, pioneering, engineering service. Connections between the amplifier and signal generators can be made by any competent electrician.

In every industry, manufacturers and users recognize and trust the name "Oilgear" for dependable, lowest-cost-per-year operation.

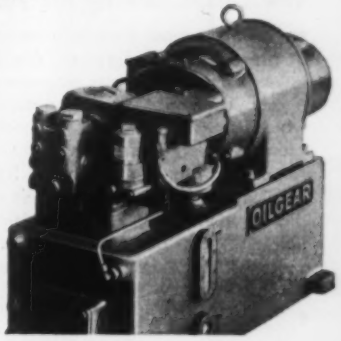
For similar practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

OPERATION: LVDT units (A, B, C, D) are actually coils with a core or slug moved axially in the coil airgap. When core is at central position there is a "null" signal. Maximum signal is emitted at maximum limits of travel — either "in" or "out." Movement of wheel or steering lever displaces core of command LVDT (A or B), producing a signal that is compared in transistor amplifier (T) with the signal from rudder stock coupled LVDT (D). Resulting difference between these two signals is called the "error" signal — built up to usable current strength by amplifier (T). Amplified signal is applied to an AC torque motor on Oilgear Two-way, Variable Displacement Pump (PV), imparting movement in amount and direction as ordered to a hydraulic servo valve — stroking pump (PV) to supply ordered direction and volume to rudder actuating cylinders (X, Y). As rudder moves, coupled LVDT (D) is displaced to reduce error signal to zero — at which point the cycle is complete. During this cycle, pump LVDT (C) has also been sending its signal to the amplifier for comparison, insuring that pump output is always under error signal control. Rapid motion of the command wheel or lever generates a large error signal, resulting in full rudder speed. Similarly, a slow command movement results in a slow rudder speed.



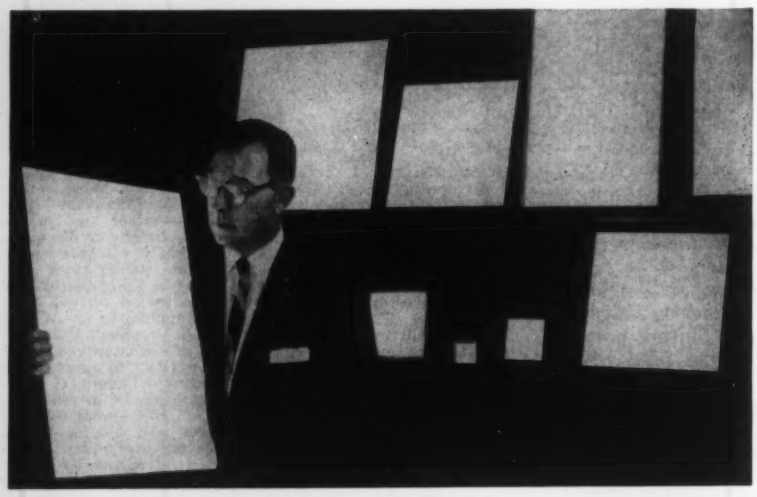
RIGHT: Oilgear Size 3, Heavy-Duty "Power-Pak" with Two-way, Variable Displacement Pump, motor, reservoir and controls . . . "as shipped," ready for installation with an "electro-feedback" system described above. This unit is now in use on a new 144' x 55' x 5' draft ferry boat of 483-ton displacement.

Similar Oilgear Systems are being used to control motion in all industry.

Circle 407 on Page 19

Air Floats Show World Time

Floats riding on air columns displayed against vertical 12-hour scales show the hour in each of the world's 24 time zones. Three additional columns at the left end of the display, developed by the Sheffield Corp., Dayton, Ohio, give a visible record of the passage of 1 sec, 1 min, and 1 hr. Air columns in the 27 tubes are controlled by an electrically driven cam. Tubes and vertical scales are positioned in front of corresponding time zones on the background map. Lights at the top of each tube indicate a.m. or p.m.



New Lamps Sold by the Square Inch

Electroluminescent panels in sizes from 2 x 2 in. to 2 x 2 ft, in standard colors of green, blue, and yellow, are available from the Westinghouse lamp division. Rayescent lamps consist of a sheet of glass coated with layers of phosphor and a conducting material. Application of current causes the phosphor to emit light which is visible through the panel's transparent front surface. Service life is "conservatively" rated at 5000 hr, and power requirements are low—0.07-w for a 4 x 4-in. lamp supplied from a 120-v, 60-cycle source. Present ideas for application of the light panels include elevator signals; safety lights; switch-plates; thermometers; clock, radio, and instrument faces; and automotive interior lighting. For decoration, special shapes, cutouts, and silk-screened markings are possible. Shaping and cutting are limited only by glass-working techniques.

Topics

"Clean as a missile" may well become a new measure of tidiness, for successful missile operation depends in no small degree on hospital-like preparations. Before launching, missiles are washed with de-ionized, mineral-salt-free water to make sure no foreign particles cling to polished surfaces. Such particles could corrode in flight and affect speed and course of the missile. Another aid to reducing contamination of missile components—or any other precision parts—are new uniforms for industrial workers. The cloth is woven of continuous filament yarns of Dacron polyester fiber and is virtually lint-free.

• • •

Dialing for diagnoses of heart ailments is made possible by a small unit which transmits heart sounds and cardiagraph signals over the telephone. The patient, with transmitter attached, sits close to the phone. At the other end of the line, the signal is carried to another electrocardiagraph for reproduction.

• • •

Russian for rubber researchers is being taught after working hours at the B. F. Goodrich Research Center in Brecksville, Ohio. Working toward mastery of technical Russian, 31 Goodrich scientists have begun a seven-month course. Purpose of the instruction is to enable the men to read Russian scientific periodicals, saving the time and expense of translation. Going rate for Russian-to-English translation of technical papers is $20 per page.

• • •

Tougher than shoe leather, a new lightweight rubber has proved in laboratory tests that it can outwear the traditional soling material. Waterproof, flexible, and nonmarking, the new combination of synthetics shows high resistance to abrasion, scuffing, and cracking. It can be made in any color.

• • •

Something new under the midnight sun, a plastic igloo is the first innovation in Eskimo housing in 1000 years. Foundation of the structure consists of two layers of plywood with plastic foam in between. Plastic blocks for the walls are held together with wooden skewers and a chemical adhesive. The finished igloo, 9 ft high and 18 ft in diameter, is light enough to be carried by four men and is snugly warm—it shuts out the noise of high winds and keeps in heat. Big advantage of this new igloo over one made of snow blocks is that the plastic model won't disappear during the summer thaw.

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

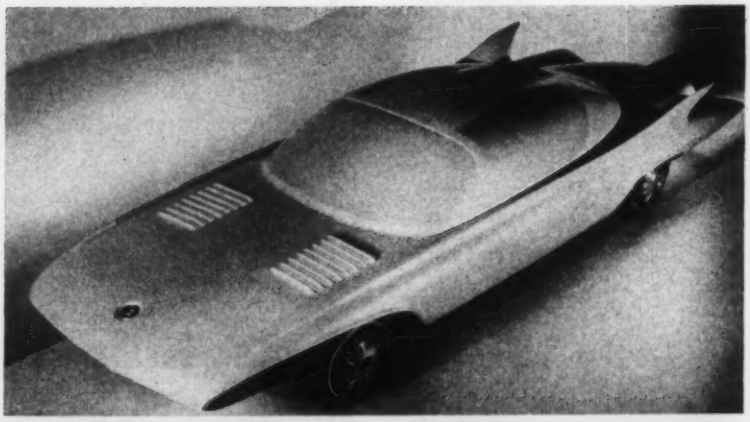
Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

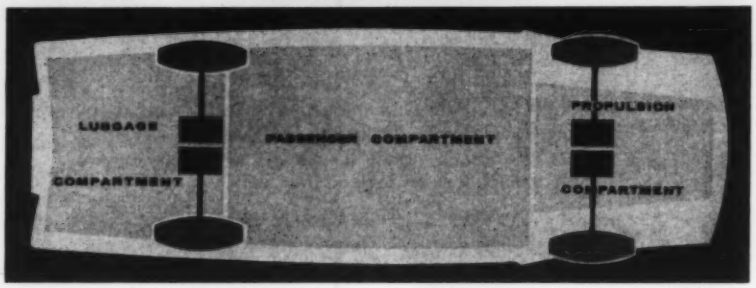
If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

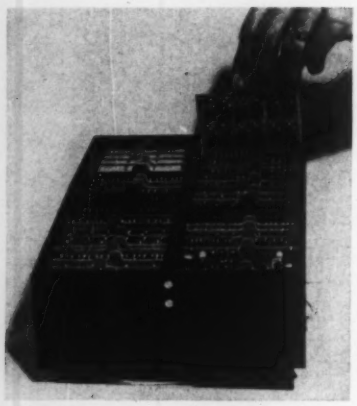
MACHINE DESIGN

Battery-Powered De Soto

Four high-speed electric motors, powered by a fuel cell (electricity from the interaction of hydrogen and oxygen gases) would provide a quiet, exhaustless powerplant for De Soto's Cella I idea car. Motors would drive through short, universal-jointed shafts to independently suspended wheels, eliminating the usual transmission, driveshaft, and rear axle. High torque of the motors would give Cella I excellent low-speed performance, and appropriate controls for series or parallel operation of the motors would assure good performance under other driving conditions. A system of differential speed governors would maintain correct relative wheel rotation. While the fuel cell would provide ample electric power, De Soto engineers have equipped the car with conventional high-capacity storage batteries. These would store energy recovered by the dynamic, or regenerative, braking power of the traction motors whenever the car slowed down, thus conserving fuel. Recent progress in fuel-cell development prompted De Soto to design an up-to-date version of the electric car.







Tricky Missile Mind Uses Cards

Plug-in circuit boards smaller than playing cards adapt this analog-to-digital converter to many modes of operation. Occupying as little as 232 cu in., and weighing 7 lb, the converter is used for guidance and stability in satellites, missiles, and drones. The encoder converts analog voltages to decimal-digit form. Normal input capacity of the CG-591 converter, developed by C. G. Electronics Corp., Albuquerque, N. Mex., is 12 simultaneous signals, but 50 or more can be scanned at rates from 100 to 300 cps. Automatic error checking assures ± 0.2 per cent accuracy.

Atom Angles

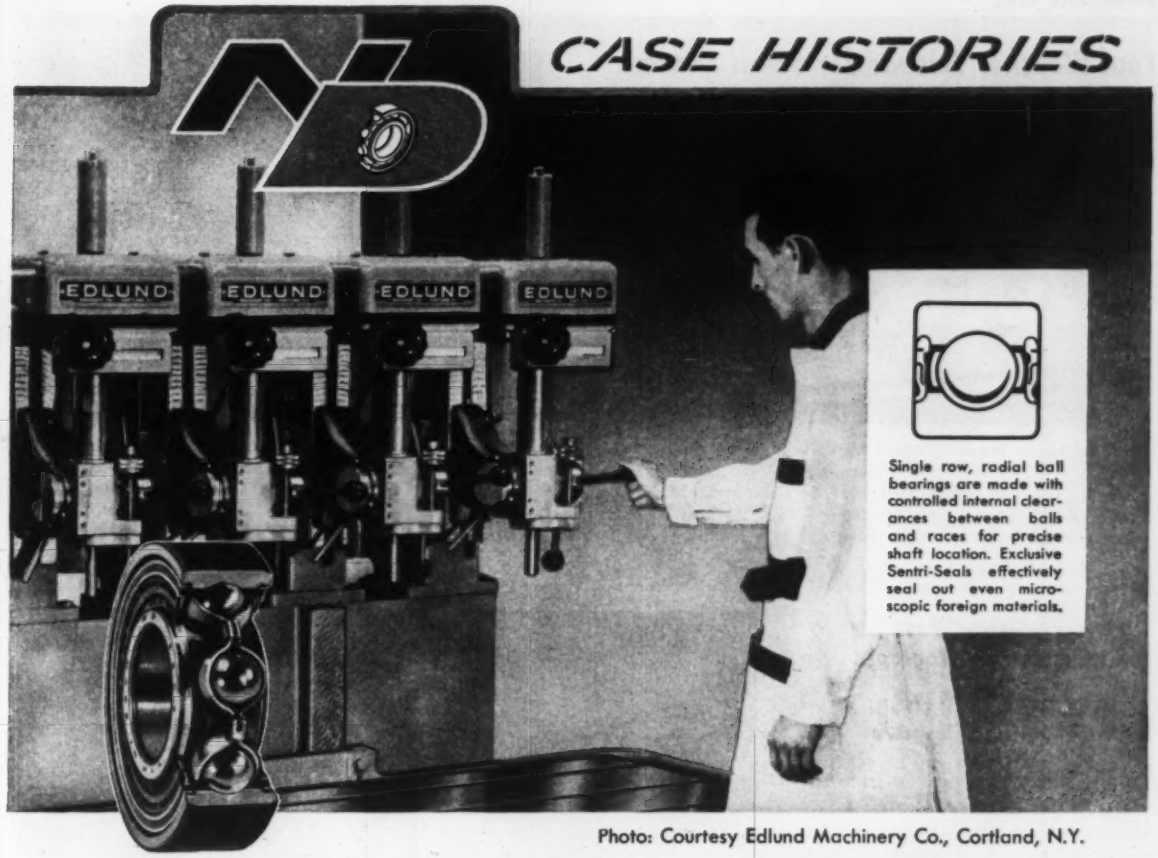
AEC will ease up . . .
on radioisotope licensing requirements now enforced for users of sealed "hot" measuring and gaging equipment. Under a proposed amendment, industrial radioisotope-using devices, e.g., thickness gages, static eliminators, etc., would be placed under "general license." That is, AEC would authorize possession and use of such equipment without requiring the user to obtain a "specific license" from the Commission. Builders of the units will still need the specific license.

Seismic "ears to the ground" . . .
will have a tougher time detecting distant underground atom blasts than first supposed. Experts meeting at last summer's Geneva conference figured that even a modest 5-kiloton explosion could easily be distinguished from the 100 or so small earthquakes and other natural seismic events that occur each year. Recent AEC tests, however, show that rock waves from bomb blasts attenuate much more than the Geneva experts counted on. Result is that a bomb-blast detection system would have to tag as man-made or natural, not 100, but 1500 borderline shocks every year.

SNAP III was a bargain . . .
at least as far as development costs go. AEC's contract with Martin Co. and Minnesota Mining & Mfg. for SNAP (System for Nuclear Auxiliary Power) set the price at a modest $15,000. But SNAP's polonium fuel charge (1/100 oz) cost $30,000 per capsule. Developers plan to try a cheaper isotope—perhaps cerium 144—to bring fuel cost down to $600 per battery.

First nuclear spa . . .
is now in operation at AEC's Brookhaven National Lab., Upton, N. Y. Heart of the new hospital-laboratory is a nuclear reactor designed specifically for medical use. The reactor delivers a neutron beam 50 times more intense than is currently available for medical use, which means reduced exposure time and greater flexibility in radiation treatments. Also, AEC's reactor-hospital combination will permit medical and biological researchers to experiment with many short-lived isotopes—they can be produced at the hospital site and used before radioactive decay.

CASE HISTORIES



Single row, radial ball bearings are made with controlled internal clearances between balls and races for precise shaft location. Exclusive Sentri-Seals effectively seal out even microscopic foreign materials.

Photo: Courtesy Edlund Machinery Co., Cortland, N.Y.

Ball Bearing Design Adds Efficiency... Cuts Relube Maintenance In Drilling Machine

CUSTOMER PROBLEM:

Tool manufacturer requires minimum maintenance ball bearing design for new high-speed multiple drilling machine.

SOLUTION:

N/D Sales Engineer, cooperating with company engineers, recommended New Departure ball bearings with exclusive Sentri-Seals in place of conventional open bearings. These ball bearings, sealed and lubricated for life, virtually eliminated bearing relubrication maintenance. In addition, these sealed bearings accounted for a savings in parts and assembly time by eliminating costly lubrication plumbing and fittings. What's more, the application has proved so successful, the customer has had other types of drilling machines redesigned to use New Departures.

If you're working on new machine designs, why not call on New Departure? There's probably an N/D *production* ball bearing that will help you, and, at a lower cost! For more information write Department T-2.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

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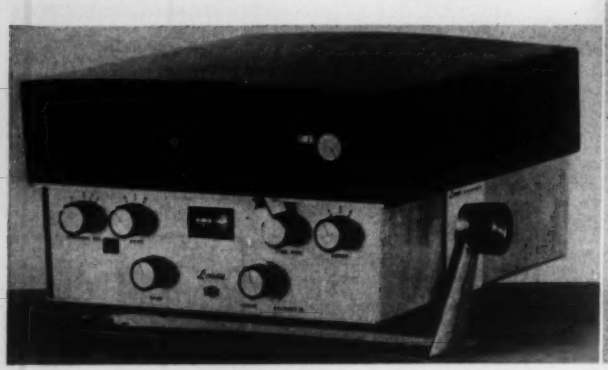
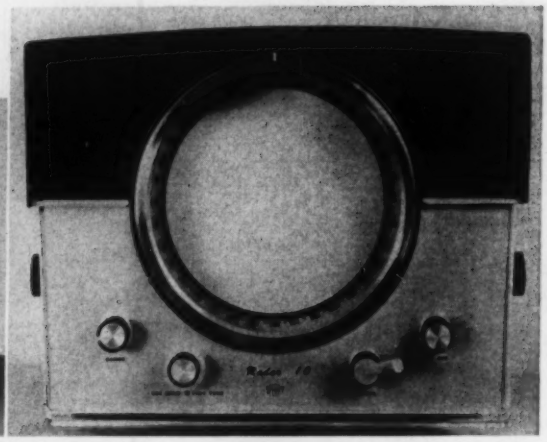
Foul-Weather Friends for Small Boaters



One-unit Loran provides small boats with radio navigation previously found only on large ships with room for bulky systems. The unit, developed by Sperry Piedmont Co. Div. Sperry Rand Corp., Charlottesville, Va., weighs 38 lb. Loran stands for long range radio aid to navigation.



Small boats come home safely in soupy weather using an economical, 20-mi-range radar system developed by Sperry Piedmont Co. Ten-inch scope shows range scales of ½, 1, 4, 8, and 20 mi. Converters are available for 32 v dc, 115 v dc, and 115 v ac systems.

Atomic Particles "Pose" For Individual Photographs

Device Traces Light Path Of 0.000001-sec Flashes

ANN ARBOR, MICH.—Light from the path of a single electron, meson, or proton can be photographed with a device developed by two University of Michigan physicists. It records tiny flashes of light, lasting only one millionth of a second, which trail behind single atomic particles as they speed through a scintillating crystal.

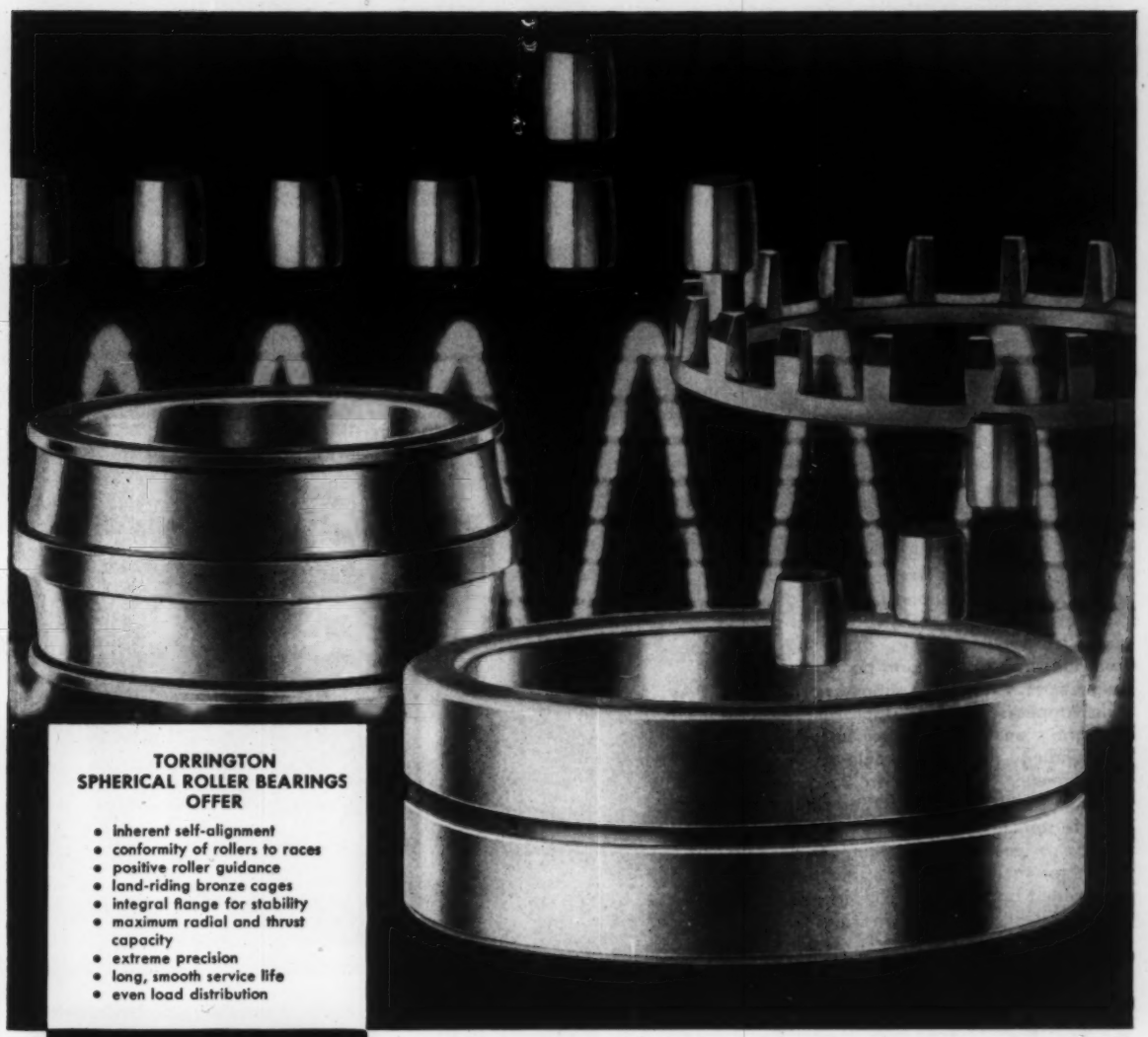
The device, called a luminescent chamber, photographs the paths of the atomic particles; it can also be instructed to photograph a certain particle path without recording any other events occurring in the crystal just before or after the selected particle in time. This facilitates study of certain very rare particles or interactions which are of greatest interest. Ultimately, a television camera may be substituted for the film and the flashes picked up on video tape.

Particle light is intensified by a series of special electron "image" tubes, made by Westinghouse and RCA. Each tube intensifies the light and focuses it on the next tube.

Parts of the luminescent chamber could be used in satellites to obtain pictures of distant stars or galaxies. A television camera would transmit data to earth.

Optical Trigger "Stops" Hypersonic Missile Models

Quick-response system takes photo 0.0001 sec after being triggered. A Kerr-cell shutter "snaps" the picture at 10^{-8} to 10^{-7} sec exposure. Shadow of the projectile falls on a light-sensitive photomultiplier, the essential part of a catadioptric light screen, and causes a signal to pass through a high-frequency, quick-response amplifier which triggers a pulse generator. The resulting high-voltage pulse synchronizes the Kerr cell and the light source to take a clear picture of the flying object and its shock waves. Avco Research and Advanced Development Div., Wilmington, Mass., uses the system to photograph flying nose-cone models and projectile emergence from gun muzzles, and to test response of photosensitive devices. This work is being carried out in connection with Titan and Minuteman ICBM nose cones which Avco is developing for the Air Force.



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- inherent self-alignment
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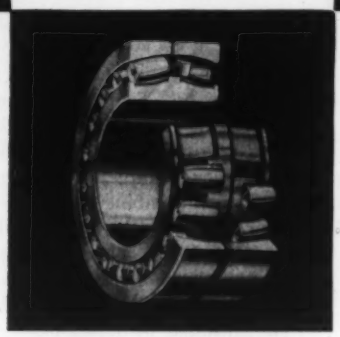
- land-riding bronze cages
- integral flange for stability
- maximum radial and thrust capacity
- extreme precision
- long, smooth service life
- even load distribution



Send for the new Torrington Spherical Roller Bearing Catalog #258

Electronics Matches Rollers and Races for Extreme Accuracy

Torrington employs the latest electronic techniques to insure precise geometric relation between components of Torrington Spherical Roller Bearings.

Roller diameters of a given complement are matched within .0001" of each other. For ultra-precision bearings, tolerances are even closer. Inner and outer races are as rigorously classified. Components are selected for assembly to provide accurate diametrical clearance. The result is bearings of unparalleled accuracy for minimum wear and friction, smooth operation and long service life.

Torrington's care for these details of accuracy is matched only by our care in matching the *right* bearing to the *right* job. In this, you can rely on your Torrington representative and the facilities of Torrington's Engineering Department. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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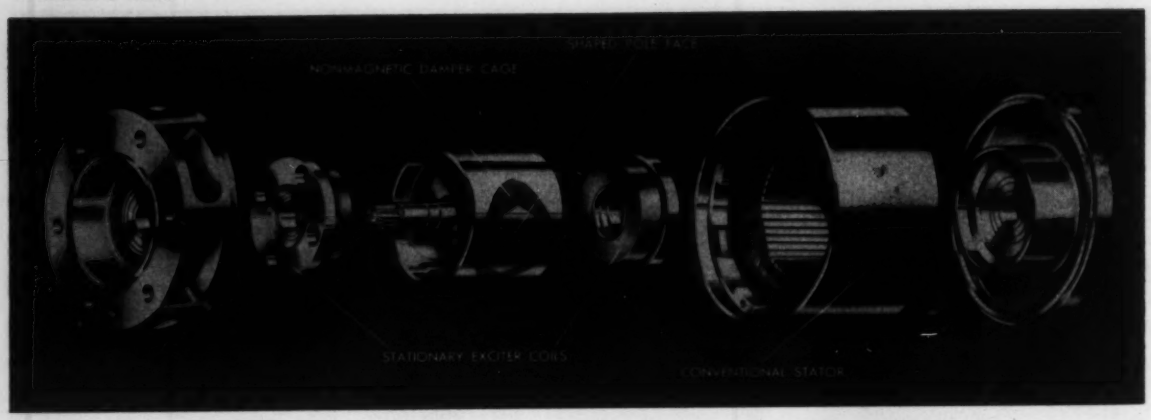
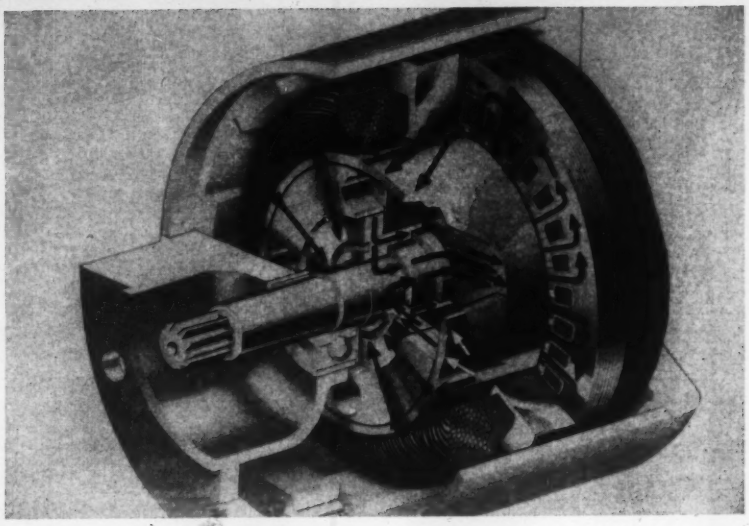


Key to operation of the Bekey-Robinson synchronous machine—called Secsyn by the licensed manufacturer, Jack & Heintz—is its unique magnetic structure employing nonrotating rotor-excitation coils. The rotor is essentially a tube supported by a "spider of spokes" on the rotor shaft (exploded view). Spokes, extending from the shaft to the north poles, are magnetic material. The shaped north pole appears as an approximate hexagon on the rotor surface. Surrounding the north pole is a nonmagnetic, but electrically conducting, damper cage. The south pole is formed by the remainder of the central portion of the rotor. Excitation for the rotating pole structure is provided by stationary coils located under extended flux-return rings at opposite ends of the rotor. Secsyn cutaway (right) illustrates flux path.



Radical Synchronous Machines Near Hardware Stage

Bekey-Robinson Patent Basis of New Brushless Line

CLEVELAND — Following a year's prototype development and service test, a unique concept in brushless motor and generator design has moved nearer to the production stage. Jack & Heintz Inc., Cleveland, under license agreement with holders of the Bekey-Robinson patent, has announced plans to manufacture and market a new line of stationary-exciter-coil generators, motors, and synchros for general aircraft and industrial application. Trade name for the line will be Secsyn (for stationary-exciter-coil synchronous).

According to Ralph J. Eschborn, J & H vice president in charge of engineering, the Bekey-Robinson magnetic design "must be ranked as perhaps the finest for synchronous machines anywhere." He listed these operating advantages:

- Long-life and reliability: J & H estimates a service life twice as long as for conventional machines. Prime reasons are the absence of brushes and rotating rectifiers and elimination of rotating copper field windings.
- High-speed operation: The Secsyn machine can be designed for any speed up to, and possibly beyond, 100,000 rpm.
- High-temperature operation: Temperature tolerance is said to be high because of ease of cooling the stationary exciter and stator windings. Rectifier cooling is simplified since rectifiers need not be located within the machine.
- Adaptability to special cooling methods.

Aside from application as an ac generator, the Secsyn magnetic structure will be used in a variety of other rotating electrical machinery. For example, as a dc generator, it will combine the basic alternator design with nonrotating rectifiers. Radio noise developed by the combination is expected to be at a considerably lower level than for conventional installations.

Synchronous-motor versions of Secsyn will exhibit good starting and pull-out torques, plus average pull-in torque compared to slip-ring machines. As synchros, the design can be applied as a transmitter-receiver, or resolver.

With appropriate auxiliary equipment, the Secsyn machine is said to hold exact speed when operated from a power supply of normal frequency tolerance.

Cool-Cathode Tubes Can Outlast Set

New Latitude for Designers Offered by Discovery

FORT MONMOUTH, N. J.—Transistors will compete in future designs with tiny but rugged radio tubes whose size will not be limited by hot cathodes. A prototype tube developed jointly by U. S. Army Signal Corps and Tung-Sol Electric Inc., Bloomfield, N. J., uses 1/10 the power of a comparable hot-cathode tube. Army spokesmen predict the new tubes will outlast equipment in which they are used.

Cathode in the new tube is a nickel cylinder coated with porous magnesium which will emit electrons indefinitely. A high-voltage field causes electron flow which makes a blue glow instead of the red light commonly associated with a hot-cathode tube.

Reliable secondary emission multipliers, potentially the world's highest gain amplifying tube, are expected to be a product of this discovery. Previous attempts at this type of amplifier have failed, generally because the hot cathode contaminated other tube elements.

Space Award Goes to Early Rocket Researcher

NEW YORK—A pioneer in the science of rocketry, Dr. Robert H. Goddard, has been awarded the first annual Louis W. Hill Space Transportation Award posthumously. Established to honor American scientists for "research in any or all of the fundamental sciences relating to space travel or space technology," the Hill award is administered by the Institute of Aeronautical Sciences. Presentation of a commemorative certificate and a $5000 honorarium was made to Mrs. Goddard at the IAS Honors Night dinner January 27.

Dr. Goddard's developments laid the groundwork for present space vehicles. He began his rocket research in 1899, at the age of 17; he first suggested the multiple-stage rocket in 1909. Direct results of his work are evidenced by the Army's "bazooka" launcher and jet-assisted takeoffs.

DRAFTING TRENDS

Whether you are filing a few hundred or hundreds of thousands of drawings, you will find easily expanded and easily altered Pack Inter-Lock units give you both the accessibility and the flexibility you need for efficient filing.

Ingenious new way to solve drawing storage problem

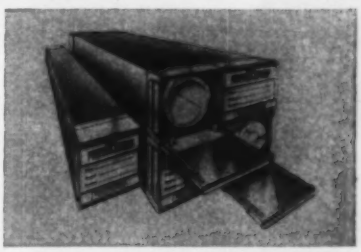
Finding a place to store drawings is becoming a tougher and tougher job every year.

One hope toward finding unused space for storage seems to lie in using what is now thought of as "dead space"...the area between the top of present filing systems and the ceiling...between files...under tables and many other nooks and crannies where it would not be practical to put a full sized filing unit.

These are some of the reasons why much interest is currently being shown in the newly introduced Pack Inter-Lock filing system.

The basic unit of a Pack Inter-Lock file is a cylindrical air-tight, dust-tight, light-tight compartment in which one drawing, or many drawings rolled together, or four separate rolls of drawings may be stored. The door of each unit contains a card serving as an index for the drawings inside. Color coded index cards, specially made for the Pack File, can be slipped into the door slot to show the current status of a drawing.

These compartments dovetail into each other and are locked into position by metal key pins that simply drop into position, thus making



stacks of files into solid units. The stacks are easily altered, permitting great flexibility in arrangements of file space.

Although especially appropriate for storage of inactive or obsolete drawings (with a complete project of up to 30 tracings group-rolled into one compartment), Pack Files are also convenient for current work. The funnel-shaped openings provide fingertip removal or insertion of drawings without damaging them. Excellent protection is assured in the crush-proof, fire-resistant compartments.

For more information on Pack Inter-Lock filing systems, write today to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

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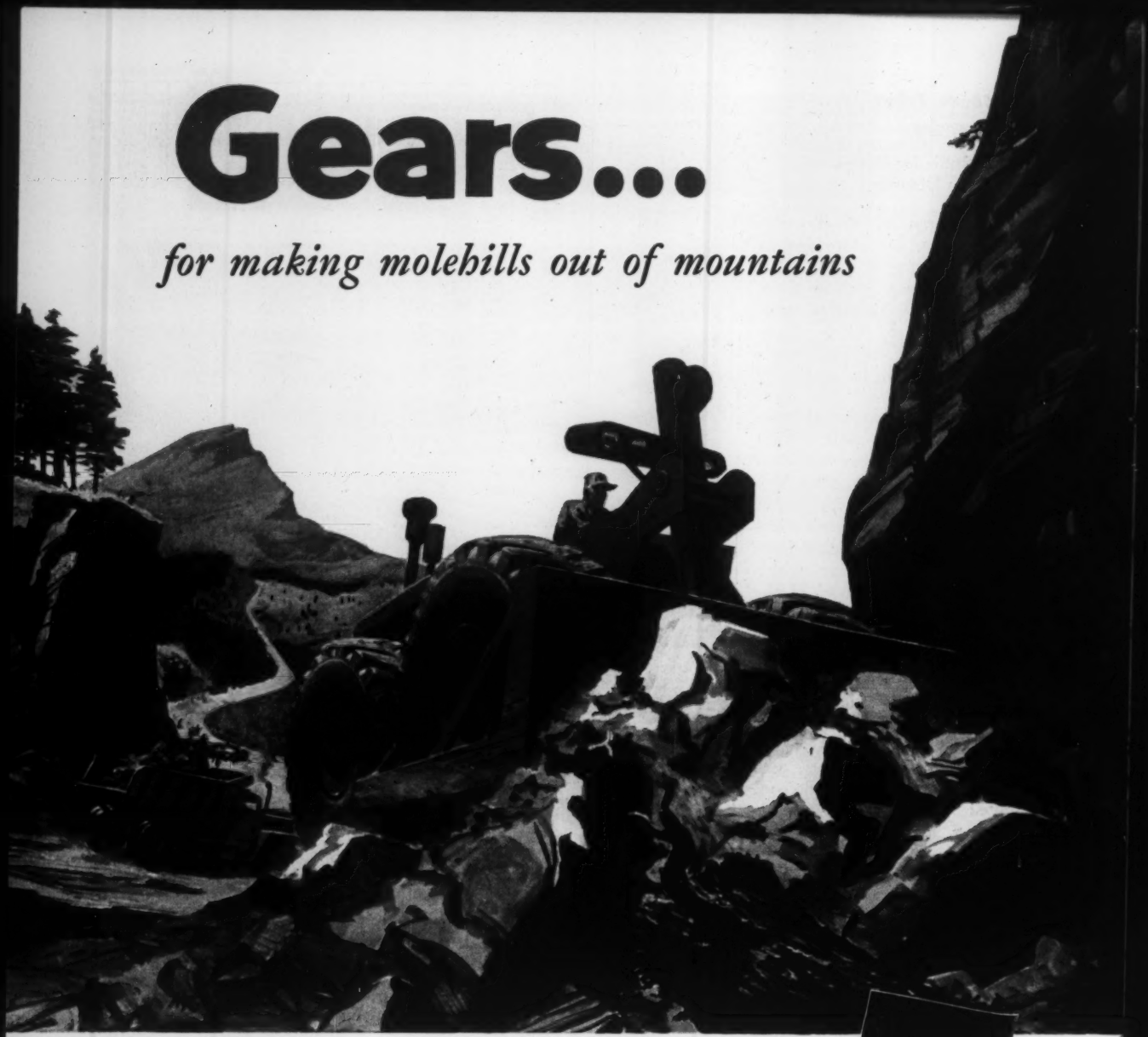
Gears...

for making molehills out of mountains



It is hard to imagine worse working conditions, and that is the very reason why the manufacturers of so many kinds of road building equipment install "Double Diamond" gears. Wherever the going is especially rough, wherever gears must give uninterrupted service on harsh, time-table schedules, you'll find our gears at work.

For low installed cost, for true operating economy and performance, and for buckling down to the hardest kind of service—nothing beats "Double Diamond."

Our salesmen are experienced gear engineers. Why not talk to one about your gear requirements?

May we send you a copy of this comprehensive catalog on the many gear types in which we specialize?

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for More Information . . .

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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Permit No. 36
CLEVELAND, OHIO

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No Postage Stamp Necessary If Mailed in the United States

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Penton Building
Cleveland 13, Ohio

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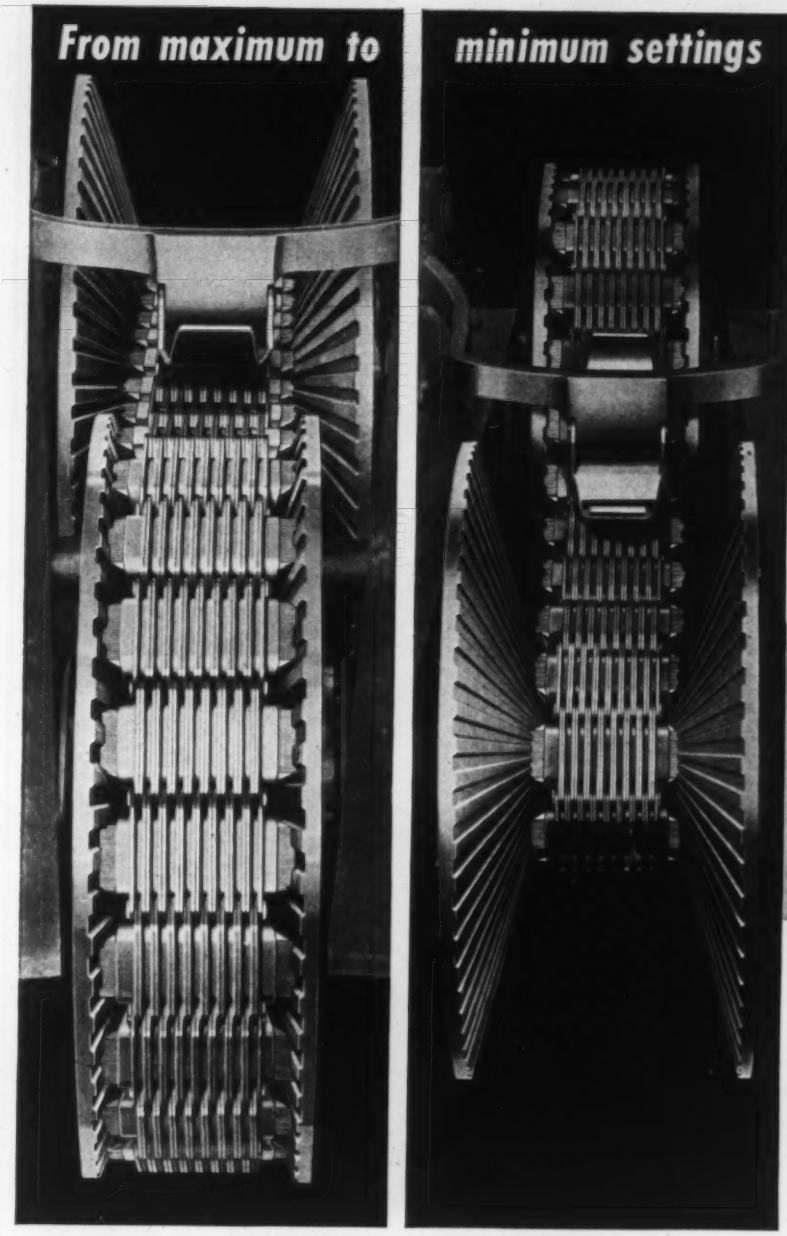
For positive, accurate speed control

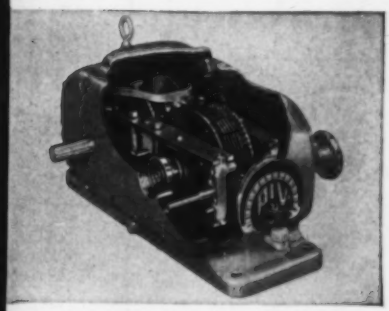
...there's nothing like P.I.V.



VARIABLE from top speed to minimum speed with no steps, no stops in between. That's Link-Belt P.I.V.—the *only* chain-driven variable speed drive. Teeth—not tension—permit instant ratio changes with no loss of speed, regardless of load conditions.

Slippage? Not a chance—P.I.V.'s chain-to-wheel grip is positive as a gear. In fact, this is industry's most accurate, most reliable mechanical variable speed drive.

Your nearby Link-Belt office will assist you in applying P.I.V. to meet your variable speed requirements. Call today or write for P.I.V. Book 2274 containing complete information on drives from ½ to 25 hp.



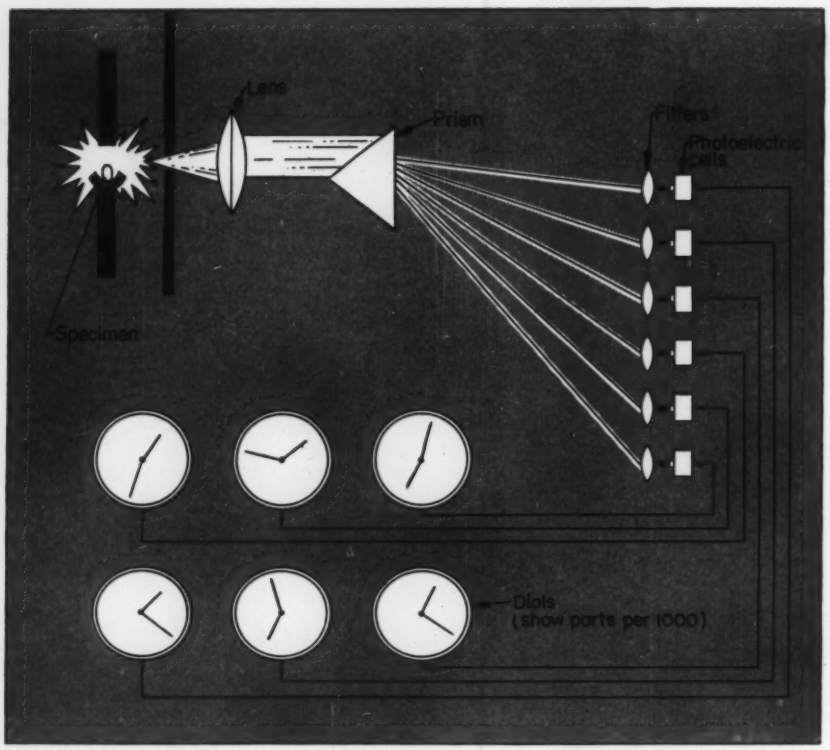
HOW P.I.V. WORKS. Exclusive self-tooth-forming chain of P.I.V. consists of packs of free-sliding steel slats which serve as teeth. Chain grips beveled grooves on pairs of conical wheels located on input and output shafts. Speeds are changed by varying the effective diameters of the wheels, as shown at left.

P.I.V. LINK-BELT
VARIABLE SPEED DRIVE

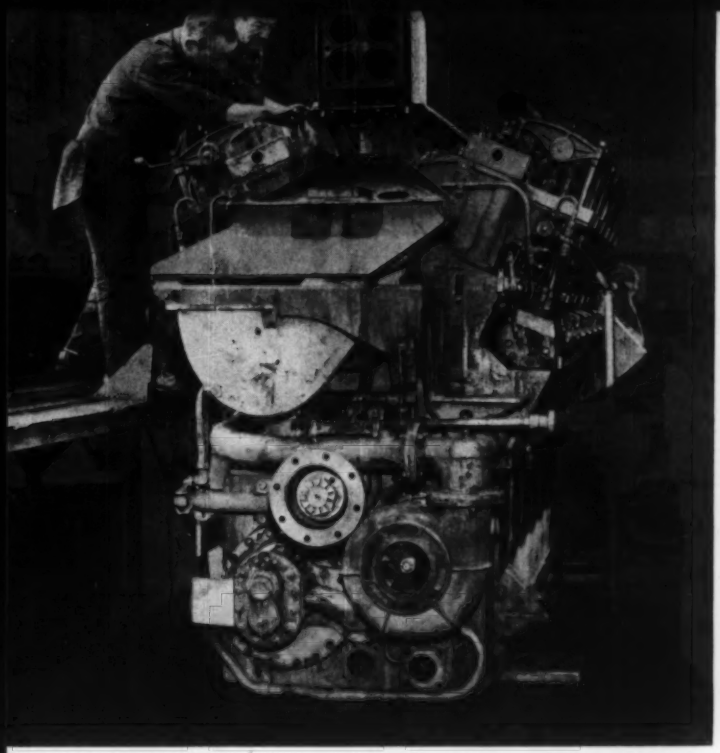
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.813-A

Circle 413 on Page 19

Telltale tests . . .



Ash specimen becomes one electrode of the spectrometer arc. Refracted rays contain frequencies characteristic of 16 elements in the ash. Beyond a small slit in the wall of the chamber, diverging rays from the arc are collimated and broken into component wavelengths by the prism. Characteristic wavelengths are further isolated by filters. Photoelectric cell behind each filter is activated, giving a quantitative indication on dials.



. . . on ashes from lubricating oil save New York Central railroad $18 million every year by giving tipoffs to trouble spots.

A new tool for engine designers . . .

Blood Test for Diesels

DIAGNOSING A LOCOMOTIVE with a laboratory spectrometer may seem like strange business. But it's old hat to scientists at New York Central's Research Laboratory in Cleveland. They've pioneered a new spectrographic technique for trouble shooting big road diesels by analyzing tiny oil samples.

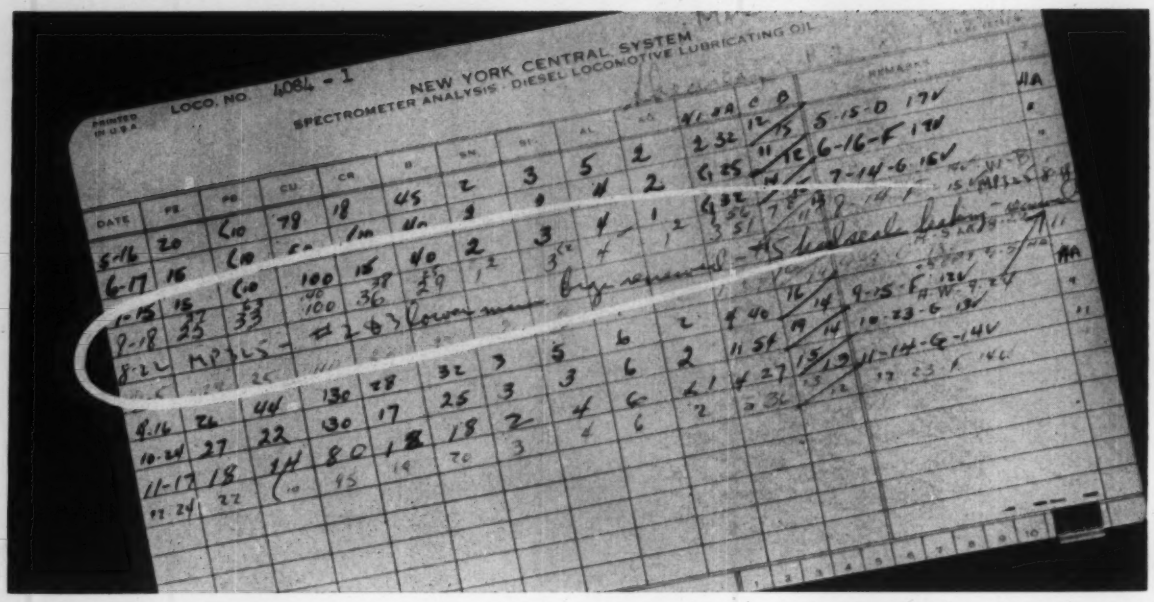
Here's how it works: A small lubricating-oil sample is taken periodically from each engine in NYC's fleet. The sample is burned by a carefully controlled process, and the remaining ash is sent to the laboratory. The specimen is quickly analyzed by spectrometer, and the content of 13 elements is checked against previous records for that engine. A sharp, unexpected change in content of any element is a telltale sign of impending trouble.

Report-back by engine maintenance crews gives lab technicians a box score on their findings. The lab has discovered that spectrographic warnings are as clear an indication of trouble as a look at the engine part would be to a mechanic. For instance: An increase in silver indicates need for a look at wrist pins; too much iron points to a deteriorating housing; an excess of chrome and sodium means cooling system leaks; high copper and lead content calls for a quick check of bearings.

Three-minute analysis of a tiny oil sample saved NYC locomotive 4084 from serious trouble last summer. When it was compared with earlier routine samples, the latest analysis showed a sudden jump in the content of lead and copper, plus a continued slow rise in chromium and sodium content. NYC scientists recognized the lead and copper as constituents of bronze bearings. Chromium came from the cooling system, along with sodium from the water. Neither could get into the crankcase unless there were a leak some place. The order was sent to 4084's terminal: "Inspect bearings and check for water leaks." The trouble was caught before it was serious; two lower main bearings were replaced, and a leak was found in a head seal.

Such incidents are routine today on the New York Central. Information on how to do it has been made available to other railroads. Recently Pacific and Rocky Mountain Express, a truck line, got into the act.

Secret of the system, say NYC



Record-card entry for Aug. 18 (engine 1, locomotive 4084) shows sharp increase in lead, copper, chromium, and sodium in the ash sample. Recorded from the spectrometer, this evidence steered the crew to a quick repair job.

engineers, is not to prescribe fixed levels of contamination tolerance, since individual engines show markedly different charcteristics in the contamination of their oils. Instead a record is kept for each engine showing the spectrographic content of 13 critical elements. A sharp change in the level of any element is cause for attention, even though it's distinctly below the fleet-average level for that element.

Designers of any internal combustion engines, by taking into account the possibilities of this technique, can improve powerplant performance and life. By adding trace elements at key trouble points, a designer may help pinpoint the locale of incipient failure. A given combination appearing on the spectroscope might then mean not just bearings in general, but a particular bearing.

Already a certain amount of qualitative assessment is possible; take the bearing case, for instance. In some engines, a comparison of the percentage of increase for lead and copper gives a definite clue to the depth of wear. This helps NYC decide whether a routine white warning or an emergency red warning should be sent out. By incorporating trace elements at various depths in wearing parts, the designer can aid the laboratory in following the course of wear in an engine component.

Antismog Auto Mufflers Reach Road-Testing Stage

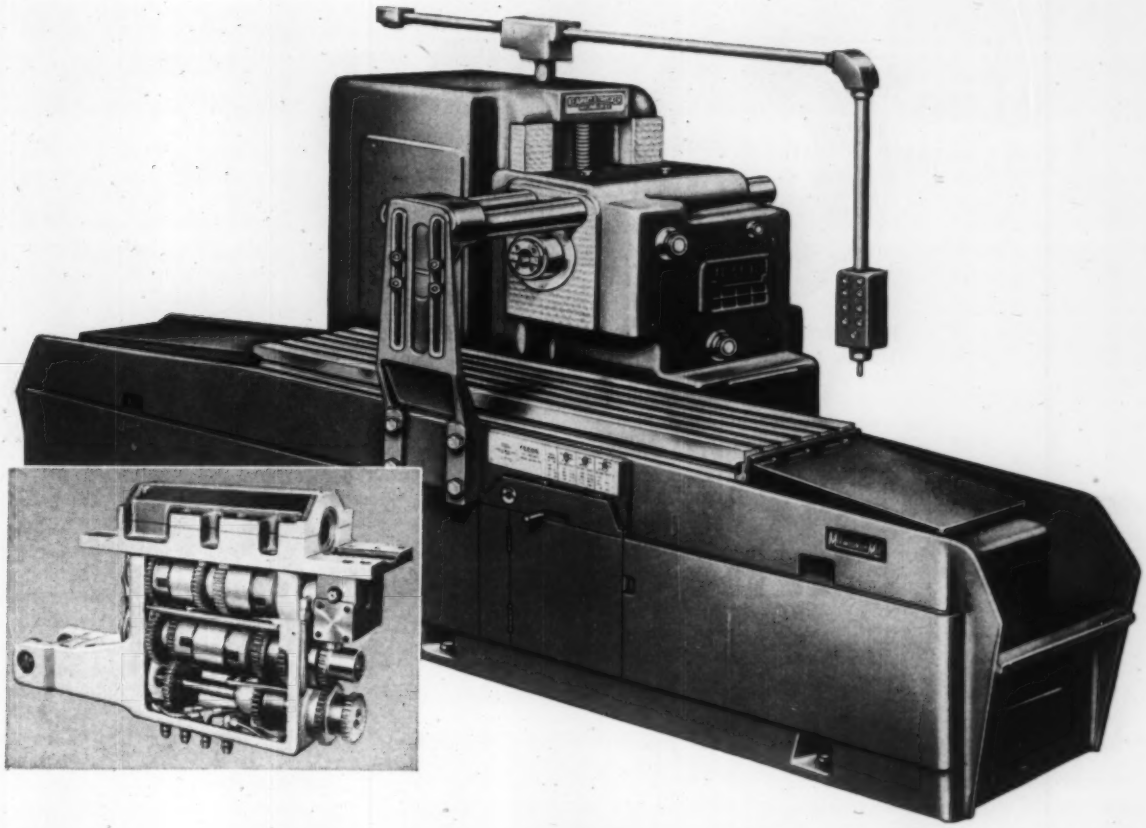
DETROIT—Although much refinement is still needed, catalytic mufflers now being evaluated by all major automobile makers are in the road-testing stage and may soon clear the air of unburned hydrocarbons.

Ford, for example, describes an experimental catalytic converter that removes 60 to 73 per cent of exhaust hydrocarbons that are believed to contribute to Los Angeles-type smog conditions. The converter, similar in appearance to a standard muffler, is packed with about 30 lb of $\frac{1}{4}$-in. diameter pellets, each coated with vanadium pentoxide. Standard exhaust and tailpipes are used. Catalyst life is currently estimated to be from 10,000 to 12,000 mi, or about one year for the average driver.

Ford officials estimate the cost of the muffler at about $150 installed, although mass production might reduce the price slightly.

Using an experimental oxidation (Houdry) catalyst and an experimental converter, both developed by Oxy-Catalyst Inc., GM has obtained results similar to Ford's as far as hydrocarbon removal is concerned. A number of practical problems must be solved, however, before the muffler can be installed on production basis:

- Noise: The converter doesn't muffle noise satisfactorily. In fact, the air aspirator on the device produces a high-pitched whine at times. Rather than use an auxiliary muffler, though, GM would incorporate acoustical characteristics into the converter design.
- Size: The experimental converter is 40 in. long, 12 in. wide, and 8 in. high, which reduces road clearance undesirably. Total weight of the system is 95 lb, including 25 lb of catalyst and 15 lb of connecting pipe.
- Heat: During tests, heat from the converter charred rubber floor mats in the test vehicle. At this rate, fuel and brake-fluid lines, as well as passenger comfort, would suffer.



Kearney & Trecker's Mil-waukee-Mil uses 6 new Twin Disc Oil-Actuated Clutches to assure *fast starting...precision braking*

Fully automatic production milling becomes a reality with Kearney & Trecker's new Mil-waukee-Mil bed type milling machines. A built-in "brain"—the Dial-a-Cycle control panel—tells the machine what to do and when to do it. Thirty to fifty per cent more workpieces are turned out every hour.

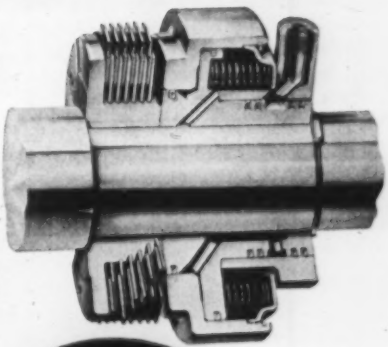
This high speed performance calls for *high energy* clutches. That's why Twin Disc Oil-Actuated Multiple Plate Clutches were chosen to control both table and spindle movements.

Four of these newly-developed clutches are located back to back in the bed: two Model DOC's for directional control and two Model DO's for feed and rapid traverse. Hydraulic interlocking of system provides instantaneous braking in case of coasting or overhauling loads from the table.

In the head are two additional Model DOC clutches—one for positive starting, the other for accurate stopping.

There are sound reasons for specifying wet-type Twin Disc Clutches. They are compactly designed and easily adapted to push button control. Since the floating or pressure plate forms the cylinder ram, ram travel increases automatically as the plate stack wears. Result: constant torque transmitting ability for the life of the plates . . . *with no adjustments whatsoever!*

Models DOC and DO are available in sizes from 3″ to 7″ in diameter. They transmit up to 137 hp and up to 690 lb.-ft. of torque. To find out how these Twin Disc Oil-Actuated Clutches can be profitably applied to your machines, send for Bulletin No. 314 today.

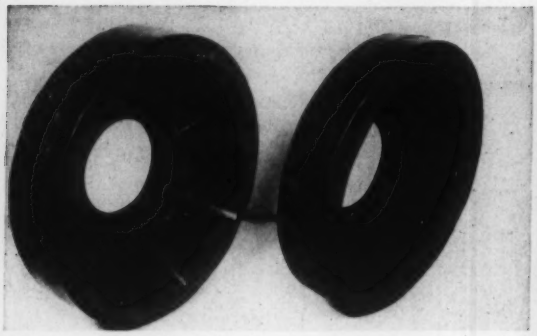


TWIN DISC

TWIN DISC

Friction Clutches and

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois



Polyester bogie wheel, above left, weighs 60 lb versus 160 lb for the conventional steel bogie, right. Since a medium tank uses 22 bogies, the weight saving is significant. Epoxy rims for trucks and jeeps, right, offer similar weight savings plus potential cost economy.

Army Will Move on

Plastic Wheels *To Cut Vehicle Weight*

Medium Tank Loses 2200 lb With Tough Polyester Bogies

DETROIT—Lightweight plastic rims and wheels that offer tremendous design and economy implications to the auto industry are currently racking up mileage on a variety of Army vehicles. Developed by Ordnance Tank-Automotive Command, Detroit Arsenal, the new units are almost past the experimental stage. If road tests confirm laboratory results the Army's jeeps and trucks may sprout plastic rims, and tanks will have plastic bogie wheels.

Production molds for several types of wheels and rims have already been designed and built by OTAC, with help from industry. Major wheel and tire manufacturers that are currently turning out wheels in evaluation quantities could easily step up their production.

No sacrifice in strength or durability is being made in favor of the big weight savings and potential cost economy that plastic components offer. In fact, fatigue tests conducted so far are extremely impressive:

- Spider-distortion, or rotary-fatigue, test requires 30,000 revolutions for standard steel rims. Plastic rims turned 178,425 revolutions.
- Bureau of Standards rim test requires 100,000 revolutions for a steel rim. Plastic rims exceeded this requirement by a margin of 4,350,000 revolutions.
- Lateral impact test: Plastic rims withstood 2020 ft-lb, which is considered satisfactory.

Material used in the new rims is

Plastic Fox, an amphibian, would need no paint or other protective coating to withstand fresh and salt water climates. Body, or hull, would have thin walls of glass fiber and polyester spaced 2 in. apart and filled with polyurethane closed-cell rigid foam. Fox would have plastic wheels, lightweight nylon-synthetic rubber tires, and might have plastic springs. The cab would be an all-plastic applique with clear plastic windshield and windows. Fuel line, oil lines, and propeller would be nylon. As a finishing touch, front and rear bumpers could be molded in energy-absorbing Ensolite that would not only furnish buoyancy afloat, but would permit a reckless driver to bump into a dock with no damage to vehicle.

a glass-reinforced epoxy, called Scotch-Ply, developed by Minnesota Mining and Mfg. Co. The rims were molded by Goodyear Tire & Rubber Co.'s Aircraft Div., with dies designed by Kelsey Hayes Wheel Co.

Tank bogies, developed by Firestone Tire & Rubber Co., are made from polyester resin precoated on glass fiber. The wheels are compression molded. Full production of these units will begin soon, according to OTAC.

While plastic wheels are an impressive development, they merely scratch the surface of potential plastics applications in the design and construction of vehicles, according to Fairchild Engine and Airplane Corp. Engineers at Fairchild's Stratos Div. have drawn up designs for an all-plastic amphibious test rig, called the Fox, which would have plastic wheels, suspension, hull, seats, and top. It would probably have an aluminum engine (with nylon fuel line), although Fairchild proposes the Fox only as a test bed for various plastic vehicle parts.

Two-Gun Tube Draws Dual Plot

Two electron guns in one cathode ray tube make simultaneous displays to give a complete record of two variables and a parameter. Nine modes of display are available; introduction of Z-axis modulation offers 27 more. Shared accelerator permits tube to maintain tolerance of best single-gun designs. Outputs from most transducers can be used without amplifying. Frequency response is from dc to well beyond 100 kc; full-scale amplitude ranges from 1 mv to 500v in 17 steps; sweeps extend from 1 sec per cm to 1 mu sec per cm. Allen B. Du Mont Laboratories, Clifton, N. J., developed the scope.

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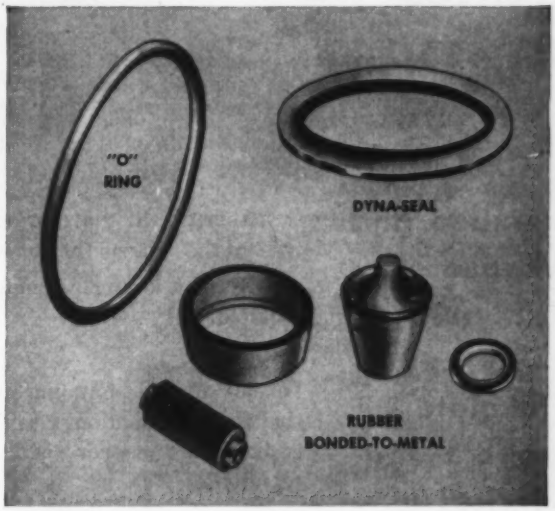
SPACE SAVING



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RUBBER BONDED-TO-METAL—Engineered parts for specialized sealing services. Exclusive processes assure accuracy, dependability and long life.

Have a sealing problem? You'll find the answer at Precision. There's a Precision Engineer ready to help you.

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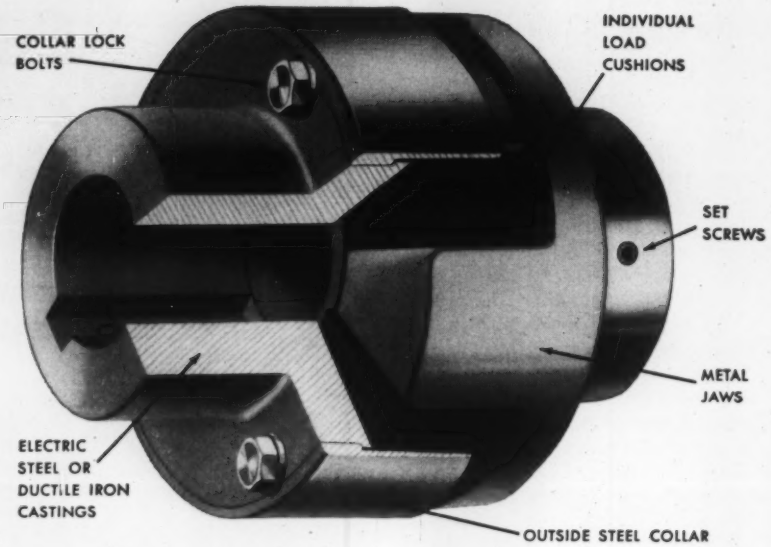
A Report To Equipment Manufacturers

LOVEJOY TYPES C and H FLEXIBLE COUPLINGS UP TO 4250 hp.



Installed and Aligned In Minutes

Just slide on the shaft, bring the jaws together and insert cushions. A twist of the bolts on the outside collar firmly retains the visible cushions.

Alignment is equally simple. Just use a straight edge. Gauges are not required.

Eliminate Trouble and Service Calls

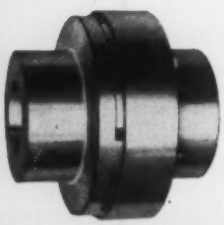
Lovejoy Flexible Couplings contain no intricate parts or mechanisms that require attention or can cause possible trouble. All parts, including cushions, are in plain sight for rapid inspection. Lubrication is never required. Water, oil, dirt or weather will not harm or in any way decrease efficiency.

The best care for Lovejoy Couplings is to *put 'em on shafts and let 'em alone.*

Outlast Equipment Life

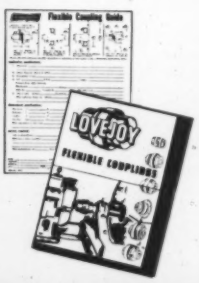
Bodies are carefully machined from electric steel or ductile iron castings. The load is entirely transmitted by cushion compression, eliminating metal-to-metal contact and resultant wear on metal parts and jaws.

Even the cushions last longer. First, they are furnished in the material best suited to the service. Second, on non-reversing loads, their life can be doubled simply by reversing or advancing.



Lovejoy Flexible Couplings can be delivered immediately from stock. Heavy-Duty Types C and H run from 18 to 4250 hp. at 1200 rpm. in a wide range of bore sizes. Other sizes and types run from .05 at 100 rpm. to 1020 hp. at 1600 rpm. to provide the most complete selection of couplings available to industry.

Request full information and ask for Catalog C-58. Give details or specifications for prompt quotation.



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SALES OFFICES THROUGHOUT THE CONTINENT

Circle 416 on Page 19

Chalk up another "first" for the Russians:

Metal Smoothing

. . . a radical heat-pressure process for boosting the wear resistance of machined-steel parts.

PROBABLY NOBODY will be unduly astonished, but evidence is mounting that engineers in the U.S.S.R.—acknowledged old hands in space technology—aren't sitting on their hands in down-to-earth fields like metalworking. As a substitute for grinding, they're reporting a new and radical technique called electromechanical smoothing. It imparts a tough, fine finish to machined parts.

Aim of the smoothing operation, possibly a distant relative of burnishing but with important differences, is to strengthen the surface and improve the wear resistance of a part. Details are still sketchy, but smoothing works something like this: A current-carrying smoothing tool—which is titanium carbide, in some instances—is forced with considerable pressure against a revolving work piece. The point of contact of tool and part is heated by the current (800-amp range), and ridges on the part are smoothed out and polished under the applied heat and pressure. The result is a hard, whirled texture on the workpiece surface. Advantages claimed for the operation are impressive:

- Surface purity is improved.
- Surface hardness is considerably increased.
- Wear resistance skyrockets.

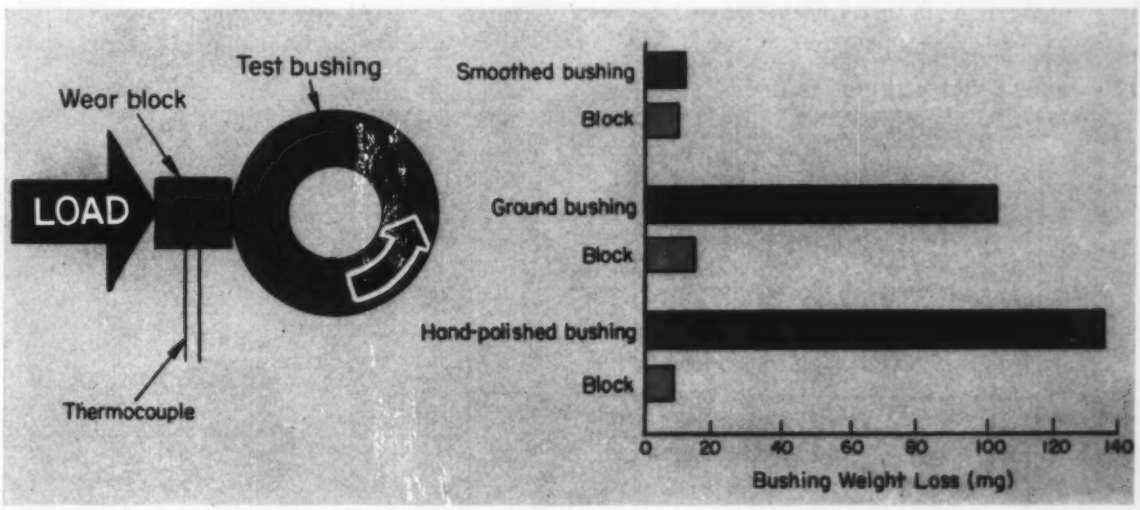
Tests Prove the Claims

Reported in detail are tests that compare the wear resistance of three carbon-steel bushings that have been given smoothed, ground, and hand-polished surfaces, respectively. Apparatus for the wear test was a modified vertical drill press. Wear blocks, which applied the load to the test bushings, were high-quality iron castings of the type used for making Russian piston rings.

Prior to the test run, bushings and blocks were impregnated with lubricant for 24 hr, since experience had shown that wear testing without prelubrication gave false data on comparative weight losses. During the tests, lubricant was applied with a drip lubricator. Spindle speed for the tests was 300 rpm.

To determine wear rate on the three bushings, each bushing and its corresponding block were checked for weight loss at 3-hr intervals. Total time of the test run was 18 hr.

Results of the tests provide dra-



1 **Wear rates compared** for smoothed, ground, and hand-polished test bushings (28 mm diam) provide evidence of the advantages offered by the smoothing operation. In an 18-hr test run, the smoothed bushing lost 10.5 per cent as much weight as the ground sample, 8 per cent as much as the hand-polished sample. Friction pressure applied was 10 kg per sq cm; spindle speed was 300 rpm; surfaces were lubricated during the run.

matic evidence of the superiority of the smoothing operation. As shown in Fig. 1, the smoothed bushing lost only 11 mg during the 18-hr test. In comparison, the ground specimen lost 104 mg, or over 9.4 times as much as the smoothed part. Loss in weight for the hand-polished part was 137 mg.

All wear blocks lost weight in the 7 to 11 mg range, and no marked differences in surface temperatures or coefficients of friction for the three test pairs were found.

Key Factors

Significant variables in the electromechanical smoothing operation are the current intensity and the number of passes made by the smoothing tool. Both affect hardness and depth of the surface layer. In Fig. 2, the relationship between hardness and current intensity is shown for smoothed samples of 0.4 per cent chromium steel (Russian designation, 40X).

Comparative smoothing passes that were made with zero current gave only a small increase over the base metal in surface hardness. Moreover, thickness of the hardened layer was insignificant, and the purity of the surface was found to actually decrease.

Further tests showed that repeated passes by the smoothing tool will promote a deeper penetration of phase transformation in the specimen and further increase surface hardness, Fig. 3.

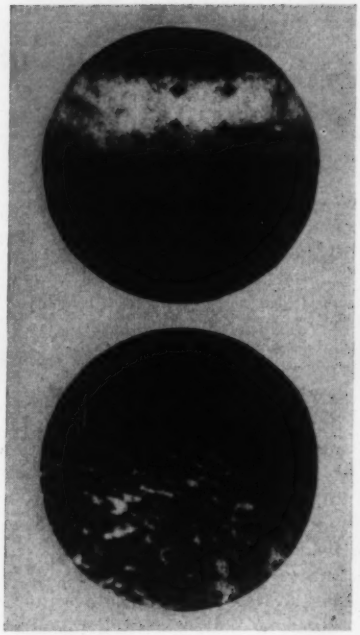
Here's Why It Works

Cross section of the characteristic surface layer of fine-grained steel after smoothing is shown in Fig. 4. Plane of the cross section is perpendicular to the direction of advance of the tool.

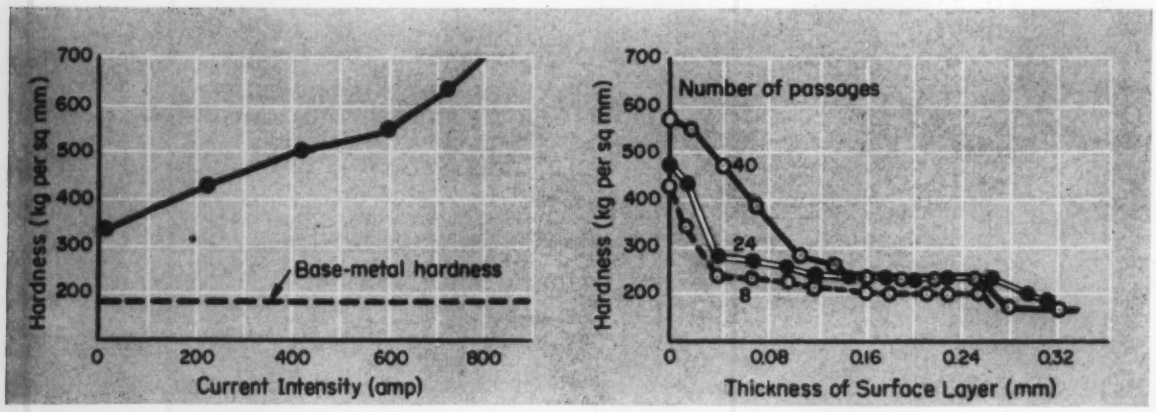
Exact nature of the white layer is unknown. Russian experimenters assumed that it results from phase transformations occurring under the action of high temperatures developed during the smoothing operation. It follows that, even with short exposures at high temperatures and pressures, fairly complete phase transformations may take place. The resulting structure consists of a special type of martensite. For this reason, diffusion of nitrogen and oxygen into the surface layer—an effect which accompanies the high-temperature friction developed during smoothing—should be prevented.

Another cross section of a specimen of smoothed steel—0.4 per cent carbon heat treated to medium hardness—is shown in Fig. 4 (lower photo). It illustrates the whirled texture of the surface layer, considerable elongation of grains in the direction of deformation, and relatively smooth transition of deformed layer to the core. The ferritic component of the structure, since it is relatively soft and plastic, deforms to a high degree.

In this specimen, surface microhardness increased after smoothing



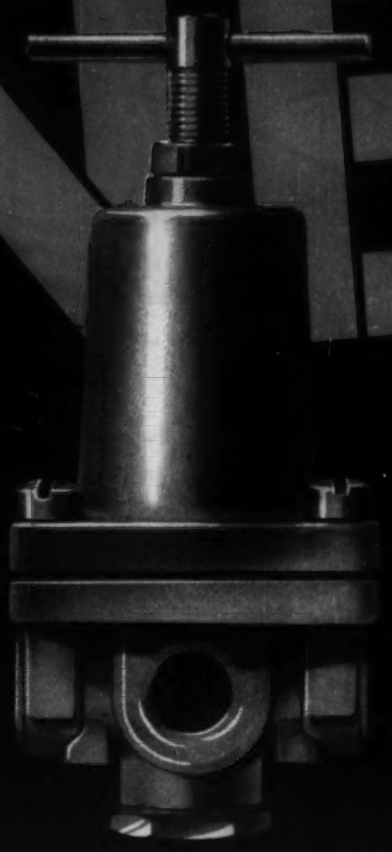
4 **Cross section** of a fine-grained steel specimen after smoothing (top) shows the characteristic white surface layer, probably a special form of martensite. Whirled texture (bottom) elongation of grains, and smooth transition of the deformed layer to the specimen core are marks of metal smoothing.



2 **Surface hardness** of a smoothed carbon-steel part increases with current intensity. Although smoothing at zero current gives a small improvement in surface hardness, layer depth is insignificant.

3 **Repeated treatment** of a surface layer by multiple-pass smoothing promotes deeper penetration of the phase transformation and greater hardness of the affected surface layer.

NEW



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PRECISION TYPE

Series 115, 116
PRECISION
LOW PRESSURE TYPE

Series 18, 19
HIGH CAPACITY
TYPE

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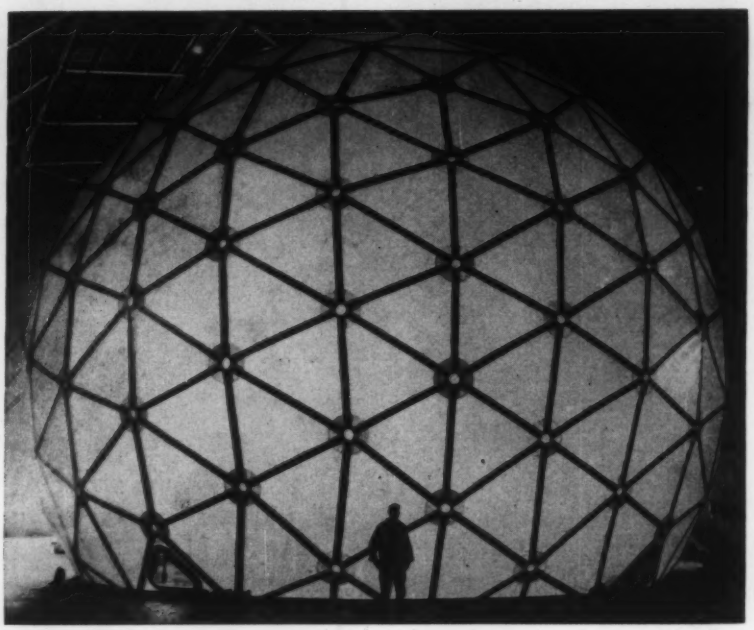
from a base reading of 157 kg per sq mm to a value of 464. Measurements indicated that high microhardness had spread only through the depth of the white layer. In the dark layer, microhardness dropped to 230 kg per sq mm.

First report on metal smoothing, by author B. M. Askinazi, appeared in the USSR journal, Metal Science and Treatment, Sept., 1958. Material in the present article is based on a translation of the original by Larissa Domnikov, Process Analyst, Northrop Aircraft Inc., Hawthorne, Calif.

Microstructure of surface layers on ground and polished samples of the same steel were found to be identical with those of the inner layers. Despite the fact that surface microhardness of the ground sample increased 41 units, the depth of the cold-hardened layer was insignificant.

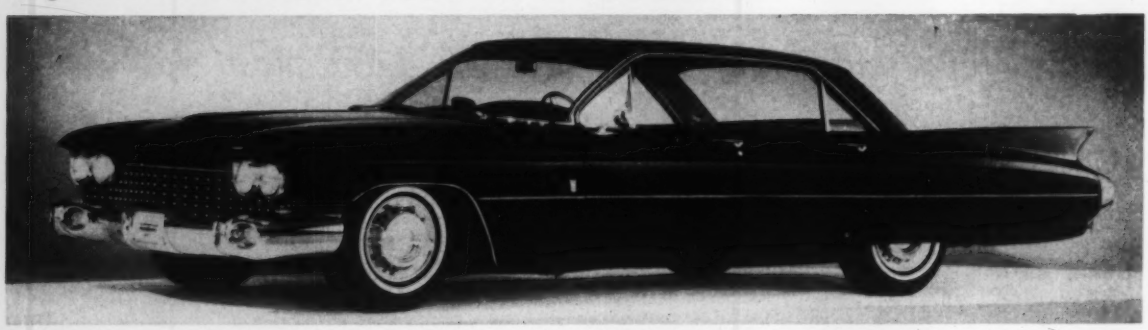
In the U.S.S.R., electrochemical smoothing is reported as finding extensive application as a substitute for grinding in the final machining of engine and vehicle components. Another use is in the restoration of worn tractor parts.



Seven-Story Radar Shack

World's largest plastic radome—68 ft in diameter, seven stories high, and weighing 15 tons—comprises hundreds of interchangeable glass-fiber panels bolted together in a few basic panel groups. Designed and built by Goodyear Aircraft Corp., the big shelter is air transportable and can be erected in the field by a six-man crew in approximately 3 days. Goodyear is under Air Force contract to build even bigger radomes, some measuring 100 ft in diameter.

Elegant Eldorado Eschews Ostentatious Ornamentation



All accessories are standard equipment on Cadillac's Eldorado Brougham. In addition to the usual power assists—from air suspension to power-operated ventipane windows—the Brougham is fitted with two storage compartments in the package shelf behind the rear seat, individual door courtesy lights, red warning lights which light when doors are open, and a clock mounted in the rear of the front seat. Engine and body specifications—345 hp, 130-in. wheelbase, 225-in. over-all length—are identical to other models in the Eldorado series. Stylewise, the Brougham is distinguished by conservative use of exterior ornamentation. Absence of rear grille and fin-mounted tail lights is particularly noticeable. Suggested list price for GM's top car: $13,075.

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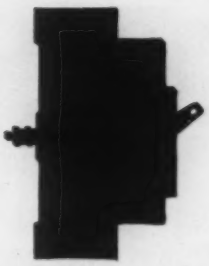
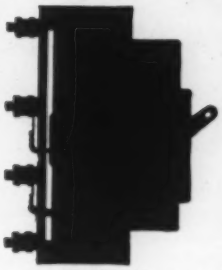
Complete information is available in the handy "Circuit Breaker Engineering Guide," Bulletin 201. Send for a copy.

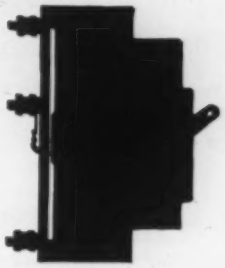
SERIES-TRIP CONSTRUCTION
Over-current sensing and circuit interruption are in series with the protected circuit. Breaker may also serve as the equipment power switch.



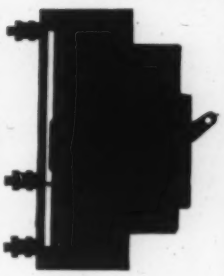
SHUNT-TRIP CONSTRUCTION
Permits remote tripping through appropriate circuit-closing contacts in remote control or safety devices.



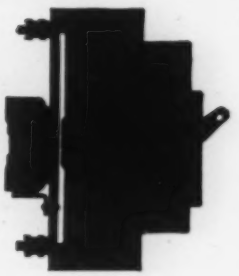
RELAY-TRIP CONSTRUCTION
Provides a separate control circuit through the coil terminals; this circuit may be at a higher or lower voltage. Can be supplied with either voltage-sensing or current-sensing coils.



CALIBRATING-TAP CONSTRUCTION
Permits control of two circuits, with tripping in response to overloads in the main circuit only. Coil may be shunted with a fixed or variable resistor to raise trip current rating.



DUAL-RATING CONSTRUCTION
Protects equipment designed to operate on either of two input voltages. Breaker has two current ratings, one overload coil.



AUXILIARY CONTACTS
Permits control of remote indicators, alarms, etc. by means of a miniature snap-action switch mechanically actuated by the breaker contacts.

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Circuit breakers

S. A. 1679

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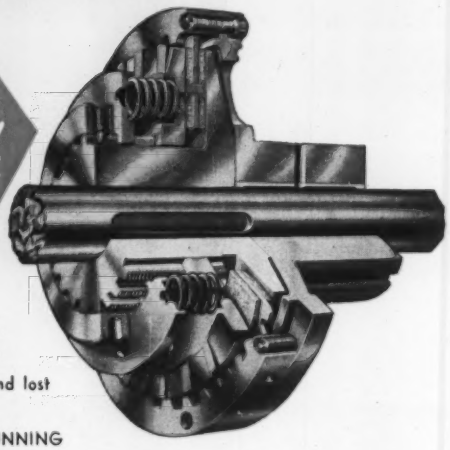
HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE *Slip Clutch*



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment— air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

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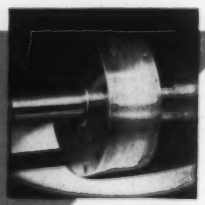
HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.



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OVER - RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

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Ultrafine Metal Powders Offer Alloying Shortcuts

CAMBRIDGE, MASS.—A newly discovered method for producing ultrafine metal powders with particles only 1-millionth inch in diameter—a thousand times smaller than any previously obtainable—promises new processes and products in powder metallurgy. Production of the minute metal particles, developed by National Research Corp., Cambridge, Mass., is attracting considerable interest from military and commercial research organizations.

The powders are, in effect, completely new materials with remarkably different properties from the base metals of which they are made, according to P. J. Clough, project director at NRC. Particles are so small that the powerful forces existing between individual molecules may be used to great advantage, he said.

First metal to receive NRC's consideration for production scale-up is aluminum. However, iron and nickel powders have also been made in the same size range and are expected to offer a large number of new magnetic and electromagnetic applications. Copper, silver, gold, cobalt, manganese, lead, zinc, and a number of other metals appear to be likely candidates.

In powder metallurgy, the superfine powders may open shortcuts to new, exact-composition alloys having superior physical properties over the best we know today, according to NRC. Simple mixing of desired proportions of various metal powders, compacting into the part required, and then sintering at high temperature may be all that is involved.

Current methods for producing high-strength alloy parts by powder metallurgy often require first melting the various metals together, then casting into an ingot, cooling, cutting and grinding into a powder and finally preforming and sintering the part. In many instances, however, the melted metals will only form alloys in certain fixed proportions—not necessarily in the optimum composition for best performance of the end product. Some of the better alloys produced by

melting may also be difficult or impossible to reduce to sufficiently fine particles for powder-metallurgy techniques.

High-temperature sintering of powdered metals involves a molecular diffusion process rather than a melting process. Since NRC's ultrafine particles of various constituent metals can be combined into the most favorable alloy composition, the result may well be superalloys that are not "in the books" today.

GM Markets Auto Gas Turbine To Promote Wide Evaluation

Tanks, Trucks, Boats Will Test Firebird III Engines

DETROIT — Reporting significant gains in gas turbine development over the past 5 years, two GM engineers told a recent SAE meeting that GM will go ahead with tooling for several prototype gas-turbine engines. The powerplants will be sold to military and commercial users for evaluation in trucks and other heavy vehicles.

William A. Turunen and John S. Collman, engineers at GM's Research Lab said further that the GT-305 turbine engine, which powers the experimental Firebird III, could be built in production quantities at a price no higher than an equivalent high-output reciprocating engine.

Particularly impressive were improvements in specific fuel consumption reported by the engineers in describing the entire Firebird series of gas turbines. The Firebird II used about half as much fuel as Firebird I, and Firebird III uses half as much as Firebird II. Thus, in cars built over a span of only 5 years, fuel mileage has been increased nearly four-fold.

The first GT-300 engine, which appeared in the experimental Firebird I and the Turbocruiser transit bus, had a specific fuel consumption of 1.63 lb per hp-hr. The engine utilized a simple open-cycle turbine, with no regenerator to recover exhaust heat. GT-304, a regenerative turbine used in Firebird II and Chevrolet's Turbo Titan heavy-duty truck tractor, burned

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Add to these operator conveniences the 675's 46-inch printing width, a mechanical speed of up to 75 f.p.m., and a fast-printing 7,500 watt lamp variable to 5,000 watts. All this, plus many other advancements, puts the "675" years-ahead of any other reproduction machine on the market. It's the modern whiteprinter that gives your operators MORE to do MORE for you.

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Circle 420 on Page 19

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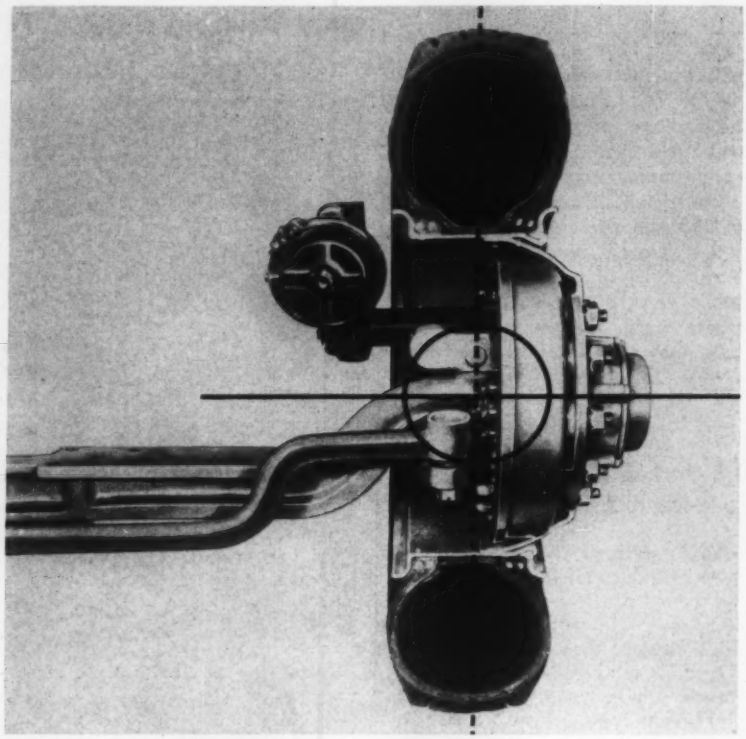
PRECISION TUBE COMPANY

Circle 421 on Page 19



Easy-Steer Axle Has Camberless King Pins

King pins pivot perpendicular to ground level in a new steering axle developed by Rockwell-Standard Corp. The pins are also mounted closer to wheel center, so that center lines of wheel and tire are more nearly common. The net effect is easier steering and longer life for all steering parts, since king pins act as pivot points only, making the axle sole support of vehicle loads. In a conventional axle, king pins not only carry weight, but also lift the load during wheel turns.

0.77 lb of fuel per hp-hr. The new GT-305 cuts fuel consumption to 0.55 lb per hp-hr. Turunen and Collman predicted that a future GT-30X engine may attain even higher performance values, making it more economical than the best comparable Diesel-engine torque-converter combinations now being used in trucks.

GT-305 is a relatively light-weight, compact engine. Length from compressor flange to transmission flange is 32 in., and dry weight, including all accessories, is 590 lb. The engine rating of 225 hp gives a specific weight of 2.7 lb-per-hp. Engine parts are arranged with a straight-through airflow path, for complete elimination of interconnecting ducts. This results in minimum pressure drop, adding to engine efficiency.

The regenerative system consists of two 22-in. diameter metal-mesh drums, which rotate through the hot exhaust air and warm the incoming air at the engine intake. All hot gases and hot working parts of the engine are contained within the drums. Heat and turbine noise are thus well insulated, providing cool, quiet highway operation.

Meetings
AND EXPOSITIONS

Feb. 26-March 1—

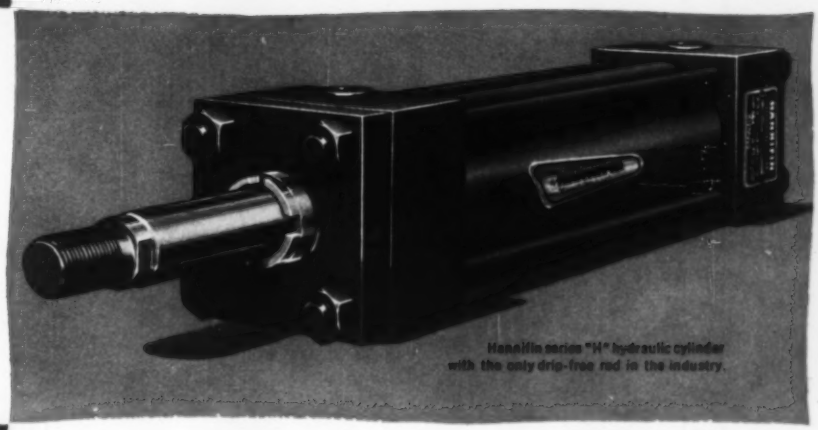
Third Annual Engineering Exposition to be held at the Electric Bldg., Balboa Park, San Diego, Calif. Exposition is sponsored by 28 technical societies, including

Circle 422 on Page 19→

Bronze cartridge gland with "LIPSEAL"* and "WIPERSEAL" can be easily replaced without dismantling cylinder.

HANNIFIN

hydraulic cylinders proved best by drip-free test



Hannifin series "H" hydraulic cylinder with the only drip-free rod in the industry.

No oil dripping on machine, product or floor proves complete sealing of oil within the cylinder by our removable, replaceable bronze cartridge gland with the exclusive "LIPSEAL"* and "WIPERSEAL" combination. (This new-type gland is shown close up at upper left.) This gland not only seals better, its long bearing surface is inside the seals where lubrication is assured.

Other Hannifin cylinder features include ground and polished rods hardened to an extra-deep case, then hard-chrome plated and polished again; cylinder walls "Tru-Bored" straight and perfectly round *before* being honed... PLUS 48-hour delivery on most standard Hannifin cylinders whenever required.

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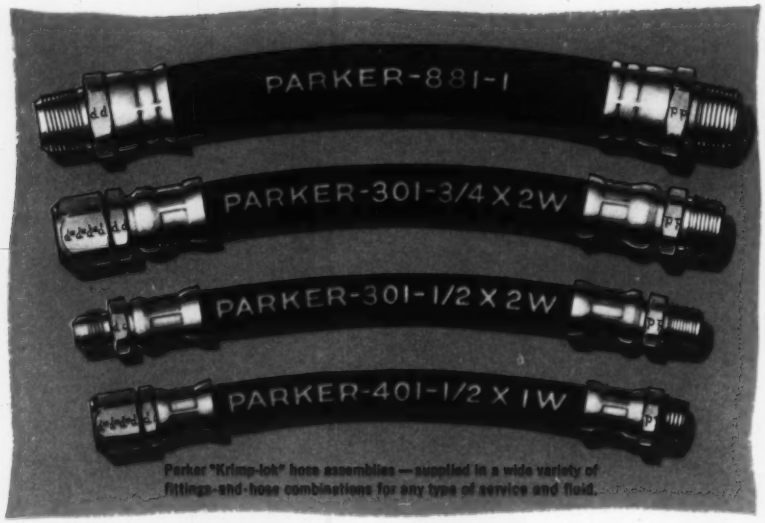

Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.

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Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

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American Institute of Electrical Engineers, American Rocket Society, American Society of Mechanical Engineers, Institute of Radio Engineers, Society of Automotive Engineers, and Society for Experimental Stress Analysis. Further information is available from D. H. Stewart, Chairman, Special Projects Committee, 422 Land Title Bldg., San Diego 1, Calif.

March 3-5—

Western Joint Computer Conference to be held at the Fairmont Hotel, San Francisco. Institute of Radio Engineers, American Institute of Electrical Engineers, and the Association for Computing Machinery are sponsors. Additional information can be obtained from Richard W. Melville, Stanford Research Institute, Menlo Park, Calif.

March 8-11—

American Society of Mechanical Engineers. Gas Turbine Power Conference and Exhibit to be held at the Netherlands-Hilton Hotel, Cincinnati, Ohio. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 8-12—

American Society of Mechanical Engineers. Aviation Conference to be held at the Statler-Hilton Hotel, Los Angeles. Additional information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 9-10—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 11-13—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 16-17—

American Society of Mechanical Engineers. Lubrication Conference to be held at the Franklin Institute, Philadelphia. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

March 16-18—

Society of Automotive Engineers Inc. National Passenger Car, Body, and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 19-20—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 31-April 2—

21st American Power Conference to be held at the Hotel Sherman, Chicago. Conference is sponsored by Illinois Institute of Technology, in co-operation with 9 technical societies and 13 other educational institutions. Additional information can be obtained from R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

March 31-April 3—

Society of Automotive Engineers Inc. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at Hotel Commodore, New York. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

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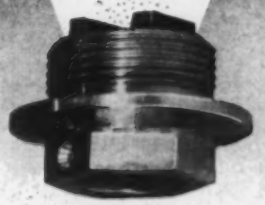

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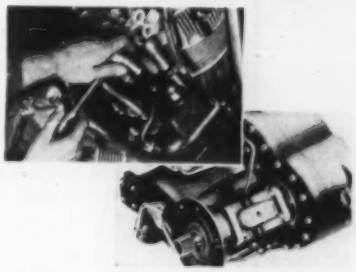

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LISLE CORPORATION
Clarinda, Iowa

Circle 424 on Page 19

←Circle 423 on page 19

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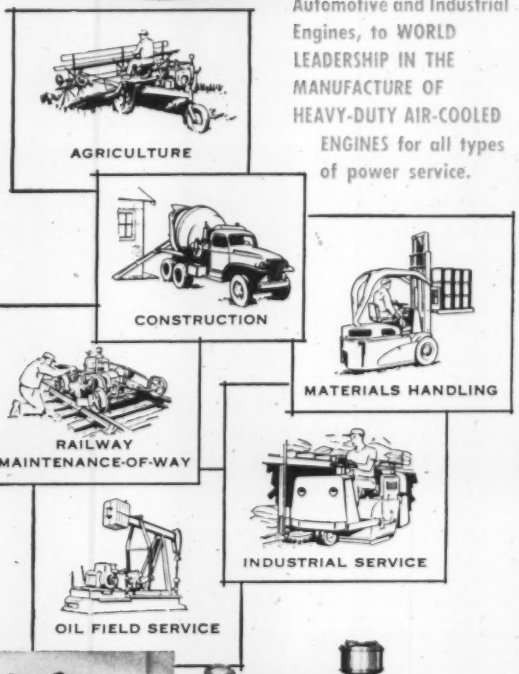
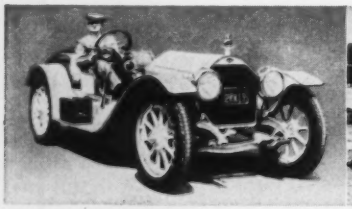
- Today the Wisconsin line comprises the most complete line of Heavy-Duty Air-Cooled Engines in the industry. They are supplied in 4-cycle single cylinder, 2-cylinder and V-type 4-cylinder models in a complete power range from 3 to 56 hp. There is a Wisconsin Engine of the right size and type to fit the job and the machine.
- Every Wisconsin Air-Cooled Engine is designed for heavy-duty service under all climatic conditions from low sub-zero to 140° F. You get the *Most Engine* for your money for MOST HP. HOURS of service.
- For 1959 Wisconsin has available a complete line of factory-built LPG Engines (including conversion kits for field installation on Wisconsin gasoline engines). In addition, we offer a new line of heavy-duty, quality-built Vertical Shaft Engines, from 3 to 7 hp.
- More than 2000 convenient Wisconsin Authorized Service Stations stand ready to provide expert servicing and factory-built parts for all Wisconsin Engines.

Constructive experience is a priceless asset. The benefits to the manufacturer, distributor and user of power equipment are many. You are best served in all respects when you specify "WISCONSIN ENGINES"... *for better service, low-cost maintenance, trouble-free operation and long engine life.* Write for engine bulletin S-237.

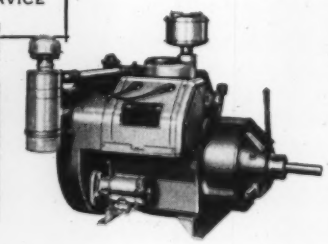
from water-cooled Automotive and Industrial Engines, to WORLD LEADERSHIP IN THE MANUFACTURE OF HEAVY-DUTY AIR-COOLED ENGINES for all types of power service.





This 1914 Stutz Bearcat, one of the most famous and rugged cars of its day, was powered by a Wisconsin Heavy-Duty Water-Cooled Engine . . . a power leader of high recognition even at that early date.

This FWD Wisconsin-powered truck, known as "No. 28," was purchased in 1921 from Army Surplus, and after many years of service is now on display at the Halliburton Oil Cementing Co., in Oklahoma.



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Coupling Design is Simple with Permanent Magnet Drives

Transmitting motion between two parts without mechanical connection may be a highly desirable goal in your new design. Permanent magnet drives often are the simplest answer to such problems. Three types of magnetic drives are generally available, and are applicable according to the desired function.

MAGNETIC DRIVE TYPES

Synchronous Drives. Both the driver and the driven member operate at the same speed. If slip occurs, the follower will slow and stop and the whole unit must be restarted. Since displacement between magnets is required for a torque to be produced, "hunting" may occur.

Fig. 1 shows a radial gap drive using Indox ceramic magnets. For maximum mechanical strength, the magnets may be glued or potted into non-magnetic holders. The optimum number of poles depends on the gap and the diameters of the magnets. Fig. 2 shows a design which can use either Indox I or Indox V material. A steel backing plate is

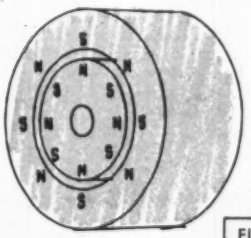

FIG. 1

desirable for maximum torque with Indox I, and is necessary for Indox V. Indox V must be magnetized with the backing plate in place, not subsequently removable. Indox I, however, may not need a backing plate when magnetizing. If backing plate is used, it may be removed and replaced without weakening the magnet. The optimum number of poles again depends on the total gap between the magnets and the thickness and diameter of the magnets.

Fig. 3 illustrates an Alnico V design. Salient poles are required for Alnico drives of this type, but are undesirable for Indox because of the high coercive force and low flux density.

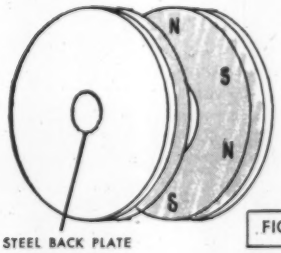

FIG. 2

Hysteresis Drives are similar in operation to synchronous drives except that the driver magnet magnetizes the follower, creating a torque coupling that is synchronous up to the maximum torque capability. If this limit is exceeded and slip occurs, approximately the same torque will be produced regardless of the rate of slip. To produce a given torque, the hysteresis drive must be larger than a synchronous drive. "Hunting" may also occur. If slip is not objectionable, an eddy current drive may produce more torque for a given magnet weight (see below).

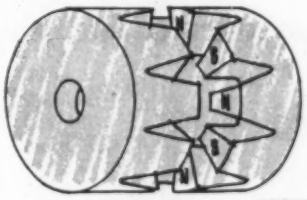

FIG. 3

Fig. 4 shows a radial gap hysteresis drive using an Alnico V driver magnet.

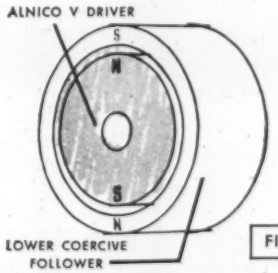

FIG. 4

Fig. 5 is an axial gap unit using Alnico V in both the driver and the follower. The optimum number of poles again depends on the air gap and the magnet diameter.

Eddy Current Drives are non-synchronous and produce no torque unless some slip occurs. The greater the load, the greater the slip. If the load on the follower is reduced, it will pick up speed until the slip is just sufficient to maintain the load torque. Eddy current drives are not subject to "hunting."

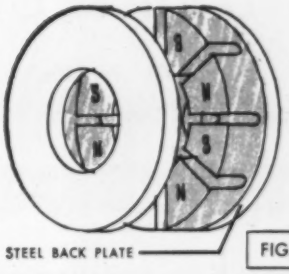

FIG. 5

Fig. 6 illustrates a basic arrangement using an Alnico V rotor.

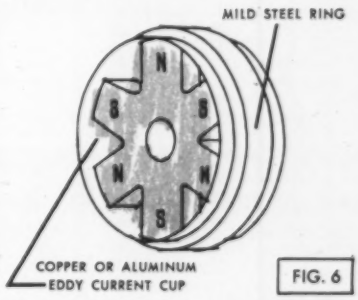

FIG. 6

TYPICAL APPLICATIONS

Synchronous drives are used extensively in pumps, where one magnet is driven by a motor and another magnet follows inside a sealed unit. The second magnet is attached to the impeller. This arrangement enables special materials to be pumped in a totally enclosed system without danger of contamination, leakage or loss of pressure.

Hysteresis drives are used for yarn and wire tension devices to maintain uniform torque regardless of speed.

A typical application for an eddy current drive is in a take-up reel, where the torque is proportional to slip.

FREE DESIGN HELP

If your product development could benefit from the application of permanent magnet drive, The Indiana Steel Products Company design engineers are ready to help with practical design recommendations, based on 50 years of experience with permanent magnet materials. Write today for this free service. Address Dept. E2.

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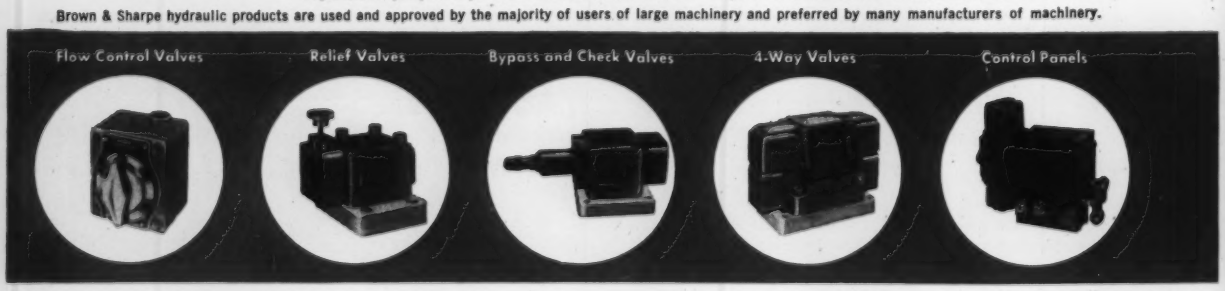

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For product catalogs or design and application information about hydraulic components — or about completely pre-engineered hydraulic power units — contact our nearest sales representative (names and addresses listed at left) or write to Double A Products Co., a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Michigan.

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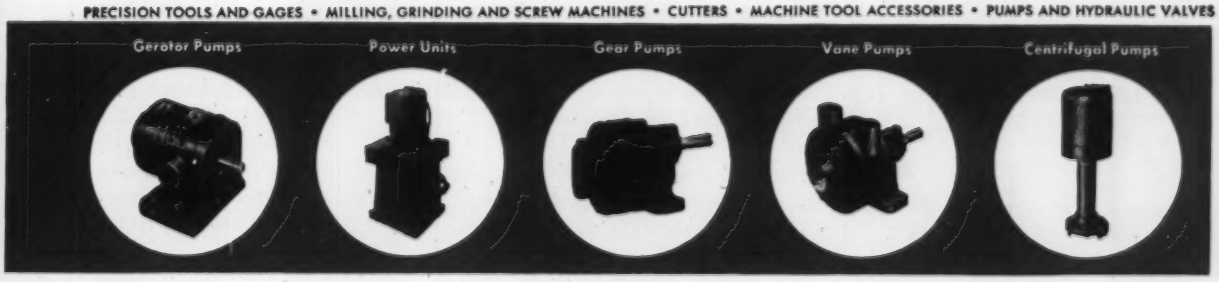


COOPER ALLOY CASTINGS BRIEFS

THE CASTINGS ANSWER CORNER

Carl Tylka, Cooper Alloy Technical Service Director, answers your questions on stainless steel castings

Q. *Cooper Alloy has recently publicized the production of stainless castings having higher physical properties than required by code. Does this result in any economies in construction?*

A. Yes, definitely. For ASME Boiler and Pressure Vessel Code designs, the casting's higher strength will increase the inherent design safety factor. For non-code designs, the higher strengths will make possible lighter wall sections. Both these features will make for more economical use of materials.

Q. *Does magnetism in an 18-8 stainless steel mean that the material's composition falls outside the normal specification range?*

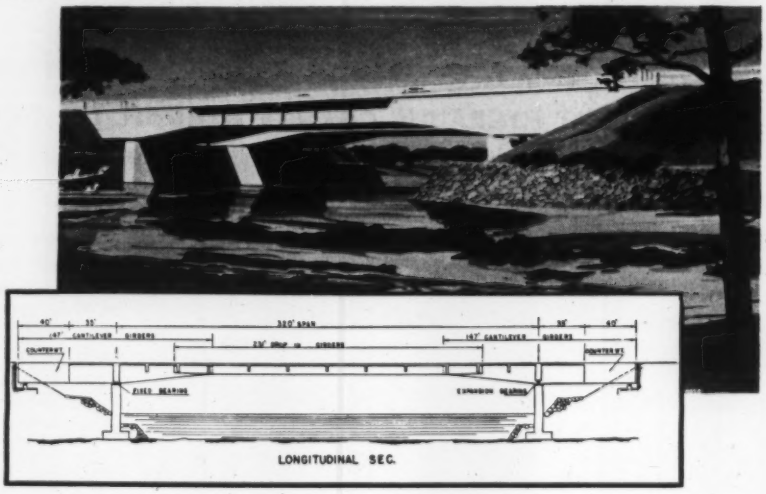
A. No. Magnetism of an 18-8 stainless depends on its ferrite content, which is variable within the boundaries of composition specs (e.g., ASTM A351, Grade CF8), and may be estimated by Schaeffler's method. Magnetism can be controlled through both chemical composition and heat treatment.

Q. *Shrink in stainless castings seems to be a common fault. Can it be avoided so as to make repair welding unnecessary?*

A. Yes, casting shrink can be avoided by proper mold design which allows for optimum metal flow, heading, and gating, and which provides progressive solidification through use of predetermined drafts or tapers. We do it all the time at Cooper Alloy.

Q. *Can ultrasonic testing give as reliable results as do X-Rays in quality control of stainless castings?*

A. No. Ultrasonic testing of stainless castings is not a feasible quality control method at present, because of difficulties of test interpretation. The inherent large grain structure of castings does not lend itself to this type test. To date, no satisfactory correlation or basis of interpretation of ultrasonic tests has been devised.



Cast Stainless Steel Bearings and Bearing Plates To Be Used on Nation's Longest Post-Tensioned Concrete Bridge Span

Will eliminate maintenance, provide long-range economies

Some 175,000 lbs. of machined Cooper Alloy stainless castings will soon be in use as bearings and bridge plates, on the longest post-tensioned concrete bridge span in the Western Hemisphere: the Oneida Lake Bridge on New York's Empire Stateway, now under construction at Brewerton, N. Y. Bridge spread is 470 ft. between abutments, with center span of 320 ft.

Normally such elements are made of carbon steel, but stainless was found by the designers, Summers & Munninger of Albany, N. Y., to provide two major advantages: greater strength per pound, which permits better load handling in the limited space available; and complete elimination of maintenance. Latter alone will save New York State hundreds of dollars annually in painting and upkeep, and allow the entire cost of the castings to be amortized in 8-10 years.

The stainless bearings, 20 in all, will allow for bridge expansion and contraction under varying weather conditions. Located between girders and piers, and between girders and abutments, they are of three types: abutment bearings (18″x9″x9″) at each end of the bridge; expansion bearings (33″x40″x11″) at the north pier; and fixed bearings at the south pier. Alloy used was ASTM A296-55, Grade CA-15 (12%Cr), having a min. tensile of 90,000 psi, and min. yield of 65,000 psi.

This unusual application of stainless steel castings is but one illustration of the many ways in which a creative adaptation of stainless castings can solve a perplexing equipment and maintenance problem. For further information on what stainless castings can do for you, write to Technical Service Department, Cooper Alloy Corporation, Hillside, New Jersey.

Circle 429 on Page 19

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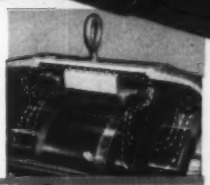

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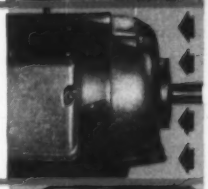
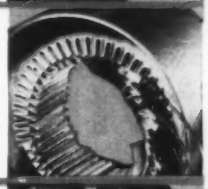
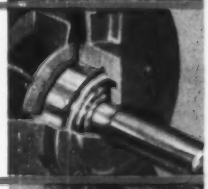


Mylar insulation increases motor life*



bearings easily inspected by removing cover plate



permanently numbered leads simplify installation and maintenance

*DuPont registered trademark.

Premium Performance

. . . at standard motor prices

R&M Series 254U Motors help pay their own way from the minute you flip the switch! They stoutly resist any hostile environment—moisture, dirt, heat, acid or alkaline fumes—and so live longer. They have push-pull ventilation that won't let dirt settle and keeps motor internally cool—and so perform with full, brisk efficiency. Their oversize bearings are quick and easy to inspect and relubricate—so your maintenance costs dwindle.

This long, trouble-free, vigorous motor life is what R&M means by "Premium Performance"—an extra reward in service and savings every R&M motor offers. These and other big, money-saving advantages shown at left cost no more . . . R&M motors carry standard motor prices!

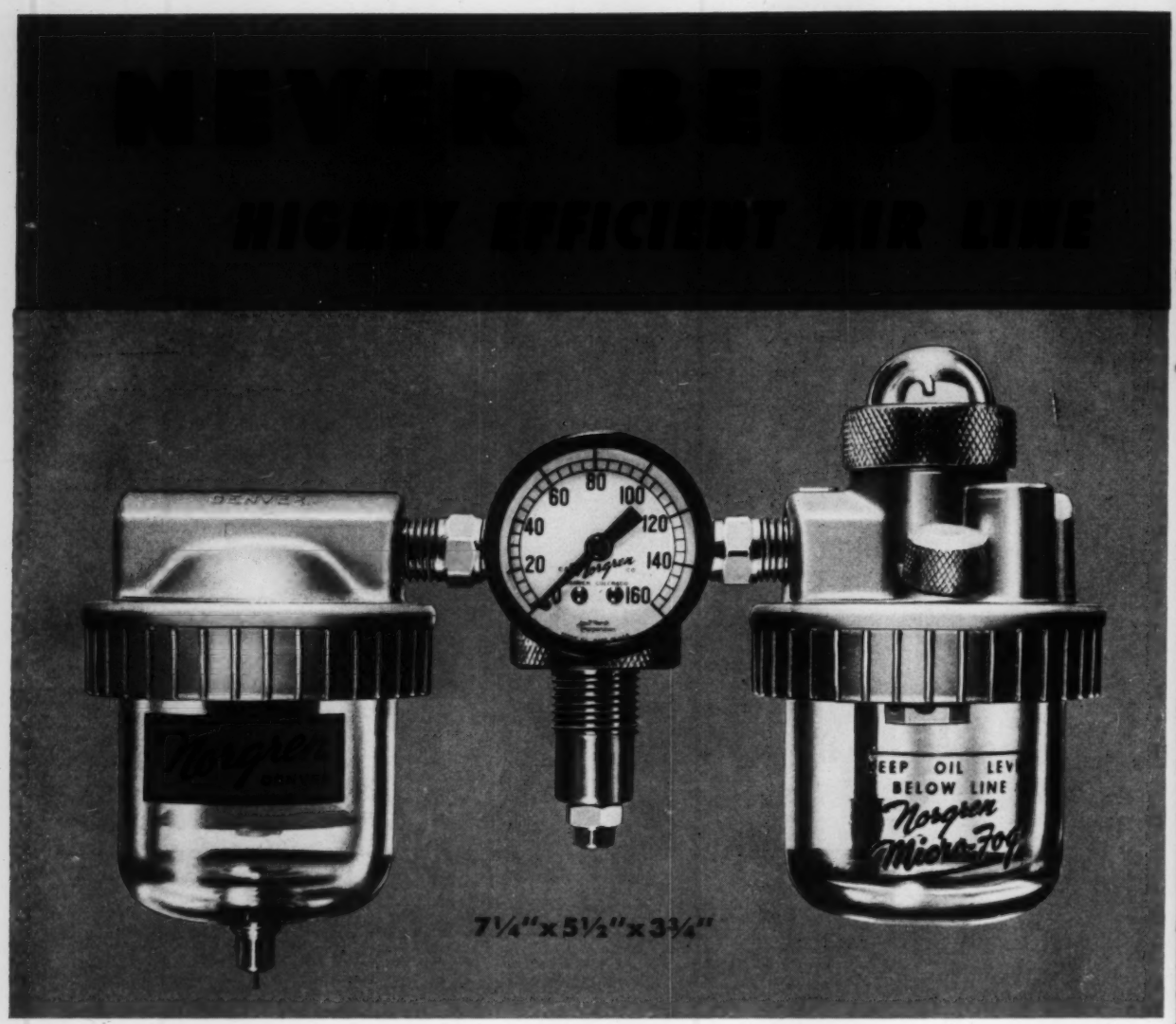
Write today for R&M Bulletin 520-MD!

Robbins & Myers build motors from 1/200 to 200 horsepower

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Circle 430 on Page 19

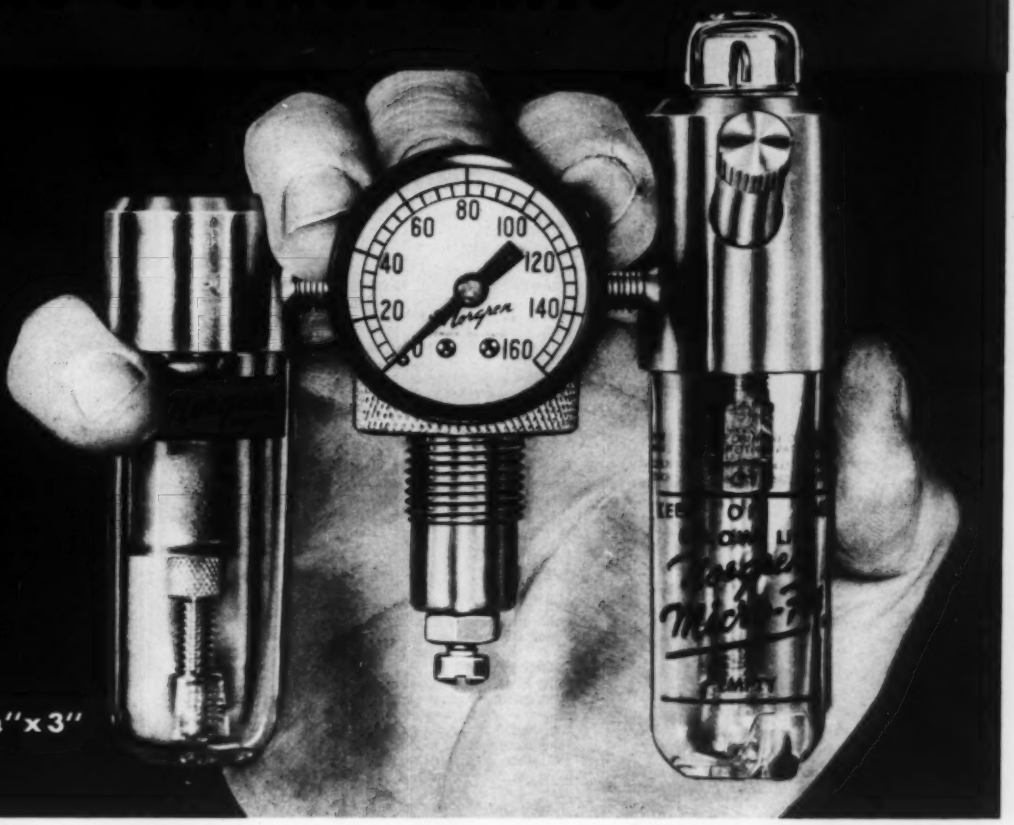


NEW SPACE SAVING *Norgren* MICRO-FOG Units

These new Norgren MICRO-FOG units: 1. Provide highly efficient compressed air processing for air tools and other air operated devices. 2. Provide efficient lubrication for bearings and machine tool components. Maximum operating pressure 150 psi, maximum temperature 120° F.

SO COMPACT...

LUBRO-CONTROL UNITS



4½"x4¾"x3"

Models Available for Air Flows from .05 to 20 cfm.

AIR LINE FILTERS

Two new air line filters provide efficient removal of liquids and solids from the air line, preventing damage to connected air equipment.

PRESSURE REGULATOR

A new small, compact pressure regulator is used for both series of Lubro-Control Units. It provides accurate, trouble-free regulation of the air pressure. Adjustable over a pressure range of 5 to 100 psi.

MICRO-FOG LUBRICATORS

New MICRO-FOG Lubricators provide efficient and adjustable lubrication for bearings, air tools, air cylinders and other air operated devices.

If it's Norgren...It's Dependable.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FOR BROCHURE NO. 915B.

G. A. NORGREN CO.

3442 SOUTH ELATI STREET, ENGLEWOOD, COLORADO

Circle 432 on Page 19

basic snap-action switches

FOR AIRCRAFT, MISSILE, ELECTRONIC AND INDUSTRIAL APPLICATIONS

more answers to switching problems

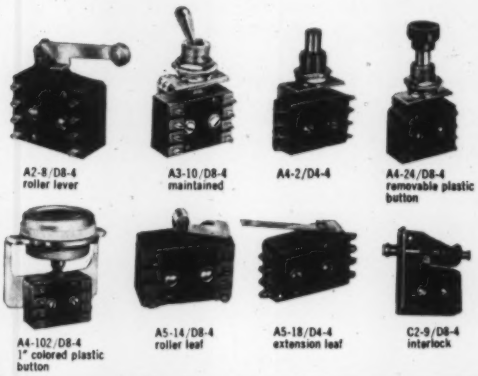
- quality engineered designed to meet human factors
- over 60,000 switch and actuator variations available
- adaptations can be made to fit your requirements

four circuit? HERE THEY ARE...

double pole

actual size

D series
DPDT, 4 CKT.
L.W.H. 1¼" x ½" x ⅜"
Elec. Rating: 15 amps @ 125/250 V.A.C.
15 amps Res. @ 30 V.D.C.
10 amps Ind. @ 30 V.D.C.
Operating Force 23 to 33 oz.
Amb. Temp. −100 to +375° F.
Termination D4 series—end solder
D8 series—side solder
Available in simultaneous, non-simultaneous and reset models. Models available with Military and U.L. approval. Write for details.



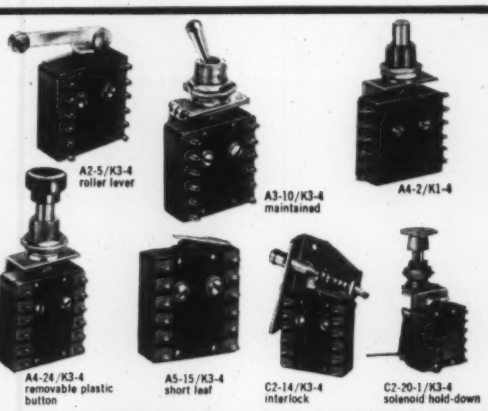
A2-8/D8-4 roller lever
A3-10/D8-4 maintained
A4-2/D4-4
A4-24/D8-4 removable plastic button
A4-102/D8-4 1" colored plastic button
A5-14/D8-4 roller leaf
A5-18/D4-4 extension leaf
C2-9/D8-4 interlock

six circuit? THESE TOO...

triple pole

actual size

K series
TPDT, 6 CKT.
L.W.H. 1¼" x .491" x 1-5/16"
Elec. Rating: 15 amps @ 125/250 V.A.C.
15 amps Res. @ 30 V.D.C.
10 amps Ind. @ 30 V.D.C.
Operating Force 40 oz.
Amb. Temp. −100° to +375° F.
Termination K1 series—end solder
K3 series—side solder
Available in simultaneous, non-simultaneous and reset models. Models available with Military and U.L. approval. Write for details.

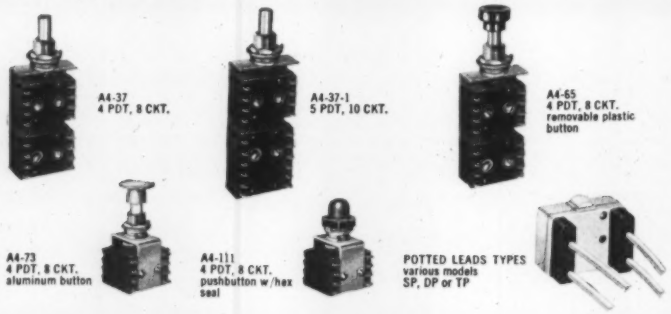


A2-5/K3-4 roller lever
A3-10/K3-4 maintained
A4-2/K1-4
A4-24/K3-4 removable plastic button
A5-15/K3-4 short leaf
C2-14/K3-4 interlock
C2-20-1/K3-4 solenoid hold-down

eight circuit? YES...

multi-pole combination actuator assemblies

Any basic switch can be adapted to multi-pole assemblies. Send us your requirements.



A4-37 4 PDT, 8 CKT.
A4-37-1 5 PDT, 10 CKT.
A4-65 4 PDT, 8 CKT. removable plastic button
A4-73 4 PDT, 8 CKT. aluminum button
A4-111 4 PDT, 8 CKT. pushbutton w/hex seal
POTTED LEADS TYPES various models SP, DP or TP

Need a special switch?

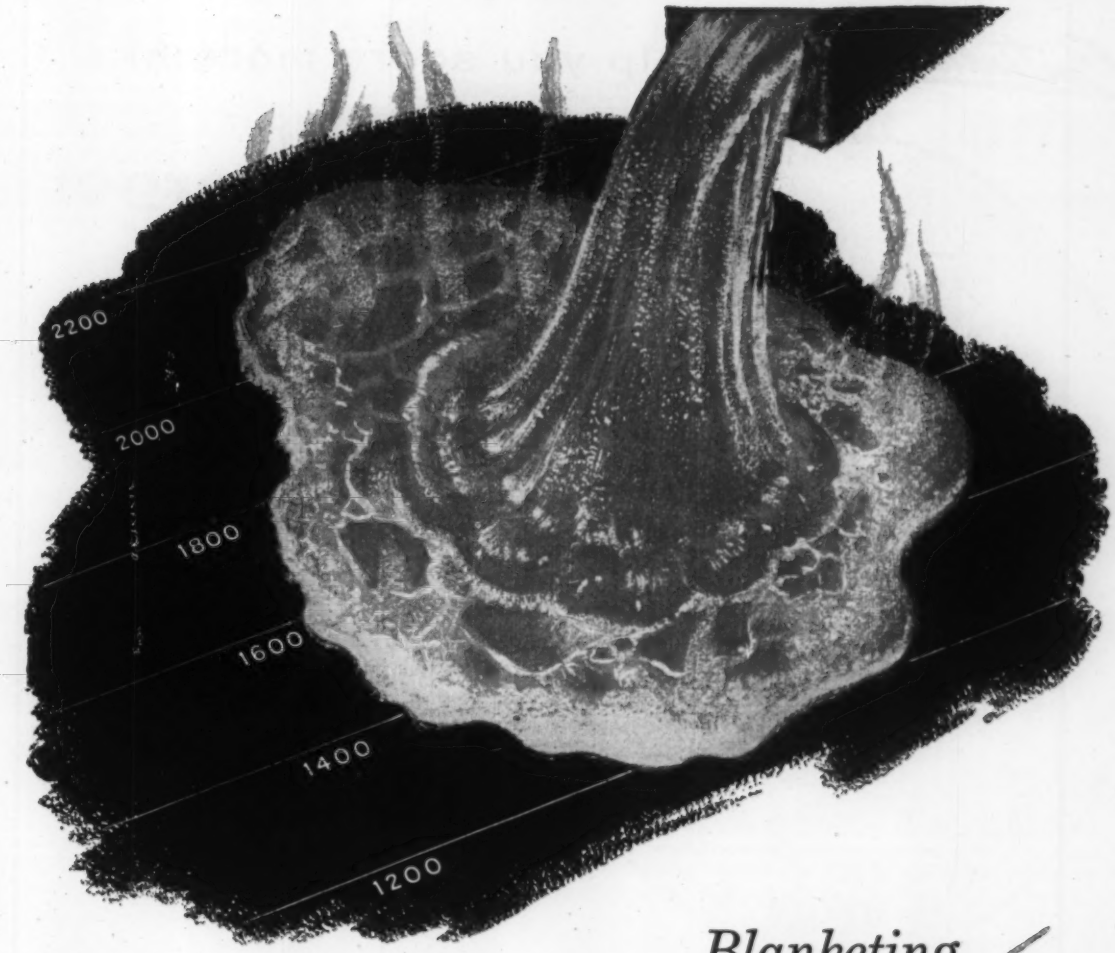
Often standard switches can be modified to do the job. If a special switch is required, Electrosnap engineering can create new switches in any quantity to your specifications. Send us your problem ...our answer can save you time and money.

Call Or Write For Specific Details On Any Switch Type

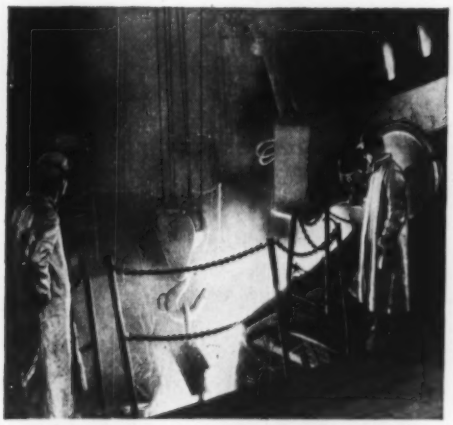
ELECTROSNAP CORPORATION

SWITCH DIVISION • 4214 W. Lake Street, Chicago 24, Illinois
Telephone: VAn Buren 6-3100, TWX No. CG-1400

Circle 433 on Page 19



Blanketing the high temperature field



Close control is exercised over every step in the production of HAYNES alloys. This electric arc furnace is part of the modern mill set-up maintained at HAYNES STELLITE.

A fairly ambitious claim! Yet we can prove that HAYNES alloys do exactly that . . . all the way up to 2000+ deg. F. Here's why. There are 12 HAYNES high-temperature alloys. Among them you will find the right combination of properties to handle any heat condition. For example, HASTELLOY alloy X has remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 is strong and resists stresses, oxidation, and carburization up to 2000 deg. F. HASTELLOY alloy R-235 is outstanding in the 1500 to 1750 deg. F. range. And this is only part of the story. All 12 HAYNES alloys are *production* alloys and are readily available. Some of them are vacuum melted; some air melted. Some are cast, some wrought, and some are produced in both forms. For the full story, write for literature.

HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 434 on Page 19

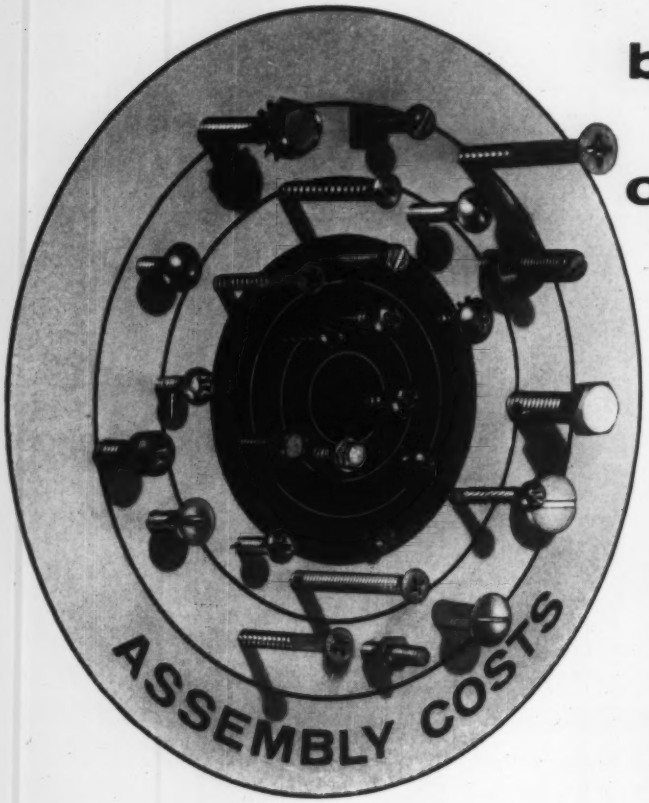
Continental can help you score more hits

on your

biggest target

for

cost reduction



Assembly accounts for up to 80% of the total cost of production. For most manufacturers, it is the biggest target for cost reduction.

If you are missing out on savings you could be making, why not get the expert assistance of Continental Assembly Specialists?

You'll find them ready and able to analyze your fastening operations and offer practical cost-saving ideas. They'll show you why assembly-men everywhere agree, ***"You can count on Continental."*** Write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

NO "FAVORITE" FASTENERS
Continental Assembly Specialists are unbiased toward any particular types . . . Continental makes all types. The fastener they recommend for your job is the one proved best by careful cost analysis.

MORE STANDARDS IN STOCK
Continental can supply any recognized standard type, style or size. Also, many fasteners ordinarily considered "specials" are available among the millions of screws constantly in stock to meet needs of Continental customers.

MORE "SPECIAL" EXPERIENCE
Continental is known throughout industry as the "specialist in specials," — leads in production of special designs. Continental is also your supply source for special-purpose fasteners, such as HOLTITE NYLOK Self-locking Screws.

MORE "SPECIAL" PRODUCTION FACILITIES
With Continental's modern, precision controlled equipment, many special shaped screws formerly machined from bar stock can be produced faster, at lower cost — with higher tensile strength and excellent surface quality.

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SCREW COMPANY, NEW BEDFORD, MASS.

HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING
THREAD FORMING •
SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

HY-PRO TOOL COMPANY... DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY

Design Data on Resilient Clutch Facings

#1

ELIMINATING CLUTCH CHATTER WITH MINIMAL DESIGN CHANGES

Experience has shown that clutch chatter, or torsional vibration, can be prevented by changes in one or more of the following factors: (1) shaft stiffness, (2) inertia of components, and (3) the friction-speed characteristics of the clutch facing material. Altering either of the first two factors can require extensive design changes.

The facing material

The influence of the facing on clutch chatter depends upon (a) the degree of change in coefficient of friction with changes in slip velocity and (b) sometimes the uniformity of the rate of change.

Figure 1 shows the relationship between slip speed and coefficient of friction for a resilient facing on three different plates (curves A, B, and C) and for a non-resilient material.

The resilient material has a fairly constant coefficient of friction at all slip speeds. The friction value of the other material, however, goes from low to high very quickly at slip speeds under 800 feet per minute.

Experience has demonstrated that chatter may occur with facings whose friction-speed characteristics are like that of curve D, i.e., a sharp negative slope at lower speeds. Thus, if chatter is caused by variations in coefficient of friction with slip-speed, chances are it can be eliminated by switching to resilient facings—with little or no change in design.

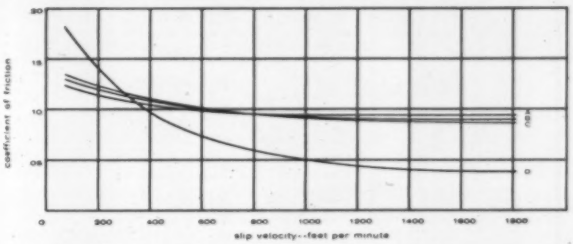


Figure 1. Results of a flywheel deceleration test. Curves A, B, and C are for the same resilient material on a waved plain plate, a flat plain plate, and a flat slotted plate, respectively. Dimensions of plates were 7½" O.D. x 6¼" I.D. Slotted plate had 1/16" radial slots dividing plate and facing into six equal segments. Tests were run in type "A" transmission fluid at 200°F. Curve D is for a metallic facing material under the same unit pressure as A, B, and C.

Clutch burn-out

A second common problem in clutch design is excessive wear or "burn-out."

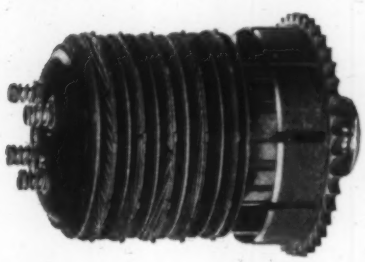
Facing wear is a function of slip velocity, length of the slip period, and intensity of pressure.

The constant, high coefficient of friction of resilient facings, even when wet, means either a shorter period of slip during engagement or that less pressure is necessary to achieve the required torque capacity.

Further, resilient facings conform to surface irregularities, providing uniform contact over the plate area and thereby eliminating areas of abnormally high unit pressure. Hence, in many cases, resilient facings prevent excessive wear and resultant clutch burn-out.

ELIMINATING CLUTCH BURN-OUT UNDER SEVERE CONDITIONS

The Triumph motorcycle clutch shown here provides a strenuous test for a clutch facing. The clutch operates at an ambient oil temperature of 250° F., engaging as many as 20 times per minute at full throttle, with slip speeds up to 4000 rpm.



Triumph engineers tested many materials to find one that could do the job without burning out. The material they ultimately selected was Armstrong NC-733, a cork-and-rubber facing.

Even though NC-733 does not have particularly high heat resistance (many other Armstrong materials have higher), this facing engages quickly, keeping slippage at a minimum. Obviously, less slippage means less heat generated—and less wear. Triumph report no problems with burned facings since they began using NC-733.

You may not require a material for operation under such extreme conditions. But, if you have any problem involving clutch facing, it will pay you to take advantage of Armstrong's years of experience in this field. Your Armstrong man will be glad to talk it over with you.

For more information on resilient friction materials and their performance characteristics, write to Armstrong Cork Company, Industrial Division, 7202 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

... used wherever performance counts

How design engineers 4 Garlock

". . . bearing seals must keep lubricants *in* and dirt *out*. The best seals are the ones that can do this efficiently with minimum friction throughout long service periods. Garlock's KLOZURE** Oil Seals meet all these qualifications. Moreover, they're available in over 3000 stock sizes!"

Cross section shows Garlock KLOZURE Oil Seal Model 53 for normal and high-speed service.

". . . there's a neat trick to making silicone sponge rubber. Garlock makes it so that it provides maximum design advantages—flexibility at −100° F., heat resistance at +500° F., shedding of water or ice, abrasion and tear resistance . . . ideal stuff for use around airframe or appliance openings."

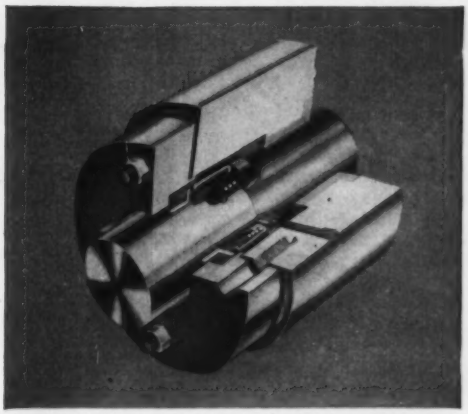
Garlock Silicone Sponge Rubber has millions of non-connecting cells which provide natural insulation. Temperature range −100 to +500° F.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

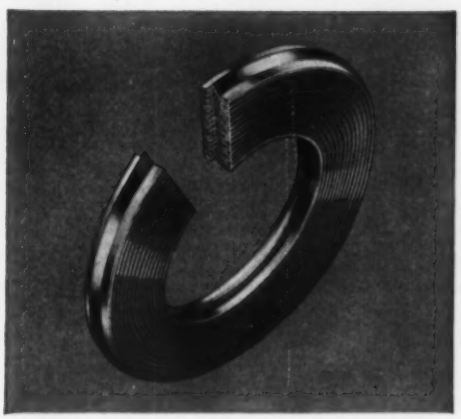
speak about these products

". . . of course, the ultimate in sealing today is the mechanical seal. In many applications Garlock's MECHANIPAK** Seals operate indefinitely. Difficult sealing jobs, however, are the real test of a mechanical seal—and MECHANIPAKS have provided a long and still growing list of successful applications against water, oils, alcohol, mild acids, and solvents. By making use of TEFLON* Garlock has also developed a CHEMISEAL** mechanical seal with the greatest immunity to corrosion and contamination."



Garlock MECHANIPAK Seal. Write for Catalog AD-150 and AD-164.

". . . Garlock Spiral Wound GUARDIAN** Gaskets are designed for various pressure ranges under established bolt loads. This is done by increasing or decreasing the number of layers, or windings, of stainless steel and TEFLON (or asbestos). Thus, a safe seal is obtained at highest pressures.



Garlock Spiral Wound GUARDIAN Gasket. Write for Catalog AD-104.

These products are another important part of the Garlock 2,000 . . . two thousand styles of Packings, Gaskets, and Seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative. Call him or write for literature.

THE GARLOCK PACKING COMPANY, PALMYRA, N.Y.

For Prompt Service contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

*DuPont Company Trademark
**Registered Trademark

Circle 438 on Page 19

SOLVING PROBLEMS COMES EASY

WITH SAGINAW b/b SCREWS!

- EXCESSIVE POWER CONSUMPTION
- SPACE/WEIGHT PROBLEMS
- PRECISE POSITIONING
- TEMPERATURE EXTREMES
- LUBRICATION
- DEPENDABILITY

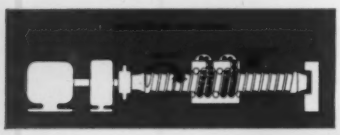
THE MINIATURE b/b SCREW

Used where *miniature* positioning/control precision and dependability is essential in telemetering and guidance systems, antenna coupler tuning, and similar diminutive actuating applications.

THE SAGINAW b/b SCREW

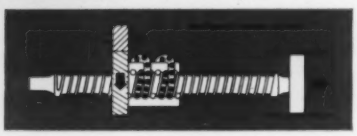
Used in afterburner controls, elevon positioners, as speed brake actuators, in clamping mechanisms for missile boosters, and many other applications.

ACTUATE AND POSITION WITH OVER 90% EFFICIENCY . . . 4/5 LESS TORQUE!



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.



1. **SAVES POWER.** Operates with almost 100% efficiency. Saginaw b/b Screws permit much smaller motors with far less drain on electrical systems, also simplify circuitry.
2. **BROAD TEMPERATURE TOLERANCES.** Normal operating temperature for Saginaw b/b Screws is from −75°F. to +275°F. In selected materials they will function efficiently at temperatures as high as +900°F.
3. **SPACE/WEIGHT SAVINGS.** Saginaw b/b Screws are compact. They permit smaller, lighter motors and gear boxes and eliminate cumbersome auxiliary equipment.
4. **NO LUBRICATION NEEDED.** If lubrication fails, the Saginaw b/b Screw will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.
5. **POSITIONS PRECISELY.** Saginaw b/b Screws will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0005 in/ft. of travel.
6. **DEPENDABLE PERFORMANCE.** Saginaw b/b Screws are far more reliable than hydraulics or pneumatics. Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance.

SEND TODAY FOR FREE 1959 ENGINEERING DATA BOOK . . .
or see our section in Sweet's Product Design File

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—3/16 to 10 inches in diameter.

Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

(Advertisement)

How do YOU select a factor of safety?

"Judgment of the highest order is needed when selecting a factor of safety for components such as hydraulic cylinders", says J. C. Hanna.

The term "FACTOR OF SAFETY" is recognized by many. The full significance of the term is understood by few. Selection of the proper factor (ratio) demands judgment of the highest order in the engineer's profession. His reputation for knowledge, thoroughness, and his sense of responsibility, are at stake. He often must consider many sub-factors with an individual weight on each.

The term "FACTOR OF SAFETY" is expressed numerically. It is the proportion that Ultimate Strength (presumed) bears to the maximum working stress (calculated). Example—5 to 1, 5/1 or 5; wherein 5 equals Ultimate (rupture or collapse) Stress and 1 equals Working Stress.

The term "ULTIMATE STRENGTH" defines the maximum resistance of a material to being torn or sheared apart abruptly by one continuous application of destructive force.

When weight or size reduction is a major factor (and not primarily because of its price per pound), the factor of safety is reduced. This is the prime and most common reason for the descending safety factor.

As we have available the newer materials, as shop methods of working materials are more advanced—the safe working value goes up—but the ULTIMATE value of most materials goes up also—and the ratio is but little changed.

With the present high (and future higher) investment in facilities per man employed, it's clear that the cost of shut-down is much more than just the cost of idle labor (high as it is, and will be)—thus a high premium should be put on reliability of equipment.

It is truer every day (as automation or its kind develops) that a chain of equipment is no more trustworthy for production than its least reliable link. A one hundred dollar link by failure might shut down a million dollar facility for a period dependent upon the accessibility of the link and/or the availability of the link or its parts.

Now—there are other failures (in strength of materials) than ULTIMATE failure.

For instance—a material may fail to recover to its original length from the application of a force tending to pull it apart, though insufficient to do so. In this case the material's "elastic limit" has been exceeded; the material has been given a "permanent set"; an "**elastic** failure" has occurred.

Elastic failure can make a part or structure unfit for further service, and repeated elastic failure by repeated application of the force may lead to ULTIMATE failure by fatigue.

Therefore, in recent years we place great importance on such terms as "elastic-limit", "proportional-limit", "yield-point" (which three are nearly synonymous) and on "endurance (fatigue) limit".

However, "Factors of Safety" are always expressed (for individual parts and simple structures) in ratio to "ULTIMATE STRENGTH" versus working stress.

It's obvious that if a material is no stronger than it is "presumed" to be, and if the stress is as high as "calculated" to be, and if the factor of safety ratio is less than 1 to 1 (say .95 to 1); then the work piece or structure is SURE TO FAIL.

If the Elastic Limit of the material is only HALF as much as the ULTIMATE (it frequently is), and if the ratio (factor of safety) is less than 2 to 1; then the work is sure to distort permanently at once, and sure to fail by fatigue breakage after a while. Therefore, the design application, knowingly on the part of the designer, of ratios less than 2½ to 1 are extremely rare, even where weight and size reductions carry a high order of importance, and stress knowledge (particularly stress due to shock) and strength knowledge is extremely accurate.

When the engineer gives thought to the following few of the many aspects of design which must be evaluated, he weighs them very carefully against any temptation to reduce safety ratio below the traditional 5 to 1. There is NO "modern or new" engineering on SAFETY FACTORS. Listed below are some of the things to consider when selecting a factor of safety:

1. Chance of loss of life or limb by failure.
2. Importance of reliability (integrity) of the part and/or uninterrupted operation of connected or related equipment.
3. Required life expectancy—(especially long or especially short).
4. Effect of variance or subnormality of machining, material, processing (heat treating, for instance), assembly, disassembly and reassembly, neglect and abuse, and misapplication of the designed part or structure.

A user might convince himself (or be convinced) to buy a device designed to a low safety factor because of low price; but when trouble ensues, neither buyer nor seller gets any comfort looking back to the low price.

There is no more hazardous way of saving money than by accepting greatly reduced FACTOR OF SAFETY ratios arrived at arbitrarily.

Competent engineers who have weighed all factors will sometimes rate and use Hanna cylinders for loads that are higher than those found in Hanna recommendation tables.

Hanna engineers, when they **know all these factors,** would agree.

The confidence that industry has placed in the name Hanna has been guarded by competent and thorough engineers for over 50 years.

Hanna Engineering Works · 1751 Elston Avenue, Chicago 22, Illinois
AIR AND HYDRAULIC CYLINDERS AND VALVES

Circle 440 on Page 19

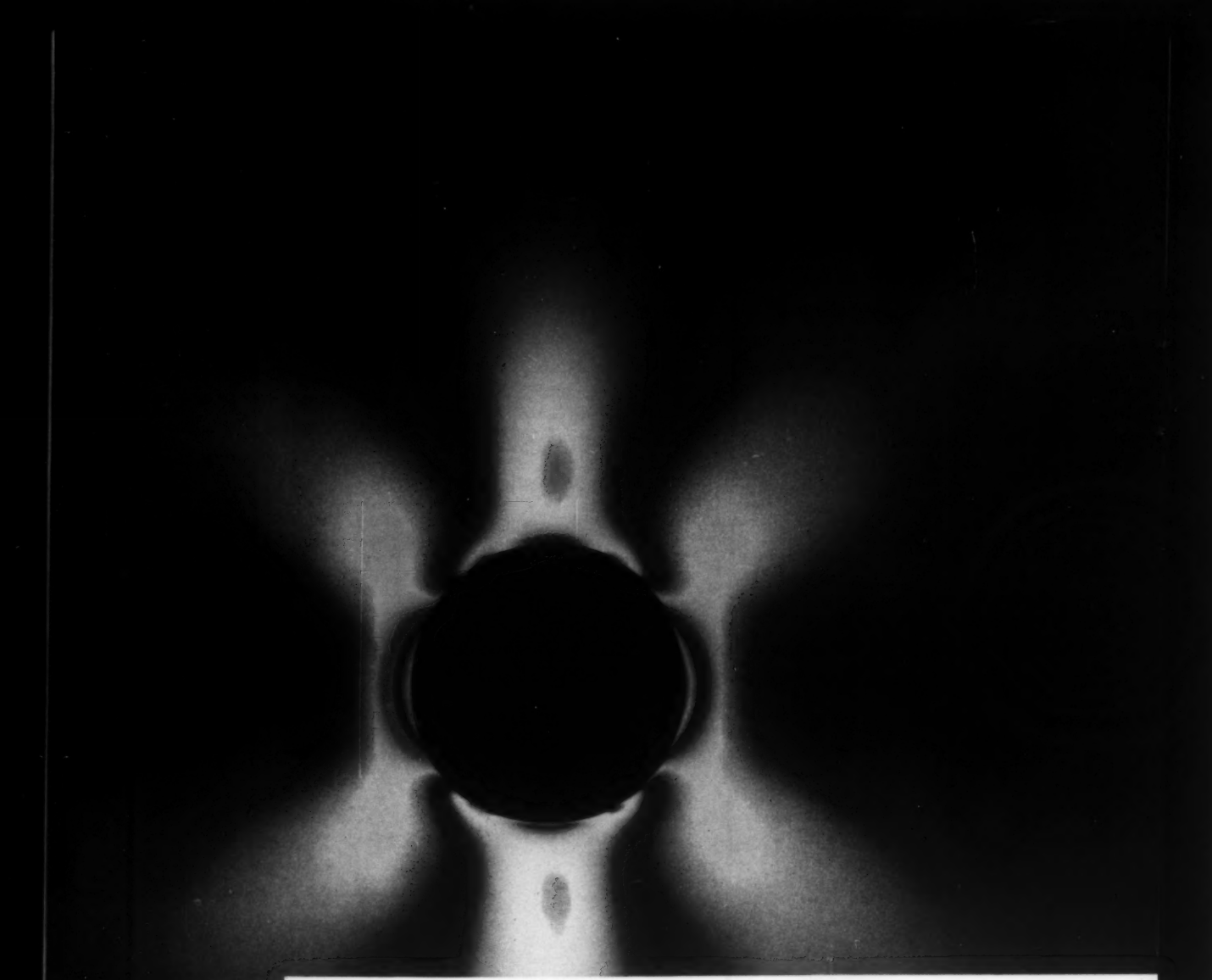


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

Strength is Malleable

The strength crucial in spiraling the heave of diesels' pistons into unresistible power, in protecting lives as automobiles hurtle down endless highways, and in every link of chain that swings massive loads overhead, is yours to mold into tomorrow's dynamic engineering achievements with Malleable iron castings. Yet Malleable provides this strength in combination with toughness, producibility and economy that makes Malleable castings the finest, most versatile metal available.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

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If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

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How to Get More Strength Per Dollar with Malleable Castings

With few exceptions, strength is the most important single design requirement for a metal part. But in the commercial production of that part, the ultimate objective is to manufacture it at the lowest possible cost. Malleable iron castings take advantage of many factors to provide the greatest strength per dollar of any ferrous or non-ferrous metal.

Great Strength Range Available

From the wide range of standard (ferritic) and pearlitic Malleable irons available, a type may be selected that meets strength requirements ranging from 50,000 p. s. i. to 120,000 p. s. i. tensile.

Table No. 1 shows these strength values and other physical measures for 9 grades of Malleable. Note particularly how high yield strengths are in comparison to tensile strengths. Because yield strength is generally the measure of usable strength, this is especially important.

Also important is the uniformity of Malleable's strength. The heat treatment given all Malleable castings produces a unique metallurgical combination of strength, ductility, machinability and impact resistance. At the same time, it relieves internal stresses so that Malleable's strength cannot be machined away, nor will it be present in some parts but missing in others.

TABLE No. 1
TENSILE PROPERTIES—
A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Ratio of Tensile to Yield %
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Economy Due to Multiple Factors

Malleable's superior strength-cost ratio is due to a combination of the casting process, which puts the metal where you want it, and the inherent economy of Malleable iron. Also, whenever machining operations are involved, Malleable castings cut finished costs significantly. Being the most easily machined of all ferrous metals of similar hardness, the cost of the finished part can often be reduced to less than that of metals which cost less in the semi-finished stage.

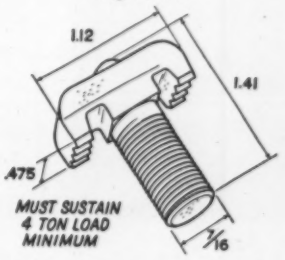
Malleable Provides Strength Plus Other Advantages

The T-bolt shown in Fig. 1 is used to assemble steel channel frames. Small but mighty, these 7/16″ bolts hold 4 ton loads. The tensile strength requirements are 90,000 to 100,000 p. s. i., yet ductility must be good and tolerances must be held to ±.005″ on the head width, and +.020″, —.000″ on the inside of the head.

In this application, pearlitic Malleable castings proved the only material consistently capable of sustaining loads over 8,000 pounds and meeting close tolerances in critical areas. At the same time, sufficient ductility was maintained to allow upsetting the spring retainer protrusion on the head.

The finished Malleable castings cost one third less than the next most satisfactory material. For both dynamic and static applications, today's Malleable castings are truly one of industry's finest engineering materials.

Fig. No. 1



Write for Free Data Unit

Data Unit 102-Strength, more fully describing Malleable's strength characteristics, is available for use by materials specifiers and users. For your copy, contact any member of the Malleable Castings Council or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

Circle 441 on Page 19

Need a Fastener that Hasn't Been Invented?

Chances are you'll pay top price for it. But by following these six rules you can avoid the high cost of becoming an inventor!*

IT'S natural to assume that, after designing a piece of equipment, you'll have no trouble finding standard fasteners to fit it. Usually such fasteners will be readily available. But what happens when you find yourself with a finished design that doesn't lend itself to any known fastening method?

The most expensive thing you can do at this point is to start inventing fasteners. Valuable man hours go into research, design, prototypes and testing. And unless you can make these fasteners in very large quantities the unit cost will be high, particularly if tooling is necessary.

Now, here are six tips that can get you out of trouble—and keep you out:

1. Remember—not all standard specialty fasteners are listed in fastener manufacturers' catalogs. The fastener company that serves you is probably tooled up for hundreds of non-standard devices, designed and produced to solve problems like yours for other customers. Maybe one would meet your requirements. You'd save the development and tooling charges.

2. There may be a stock fastener available for this job that hasn't come to your attention. Discuss the problem with the fastener manufacturer. If he has nothing in stock, he may be able to modify one of his standard devices at very nominal extra cost.

3. Don't overlook free professional help! Your fastener manufacturer will be glad to offer advice and design service—he does it for everyone else. Unload the problem on him, and let his experience work for you.

But you'll save money if you avoid specifying the fastener that hasn't been invented. By following the next three rules you can usually keep from reaching the point where a non-standard device might be necessary.

4. Go into the fastening problem during the early stages of design. Design your closures with standard fastenings in mind. You won't be left with the costly choice of inventing a fastener or redesigning your product.

5. Keep a complete file of fastener manufacturers' catalogs. Your product designers seldom are fastener specialists too, but they can have complete information available when they need it—at the design level.

6. Work closely with the Fastener Sales Engineer who calls on you. He's trained and paid to help solve your problems. Take full advantage of this service.

Whether you need a standard specialty fastener or the one that hasn't been invented, Southco is well qualified to invite your inquiries. There's no obligation on your part. It's part of our business to offer free consultation at the design or production levels, on items of your own product line, or on those involving military specifications.

Send today for our forty-four page Fastener Handbook No. 8, just printed. Write to Southco Division, South Chester Corporation, **237** Industrial Highway, Lester, Pa.

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Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

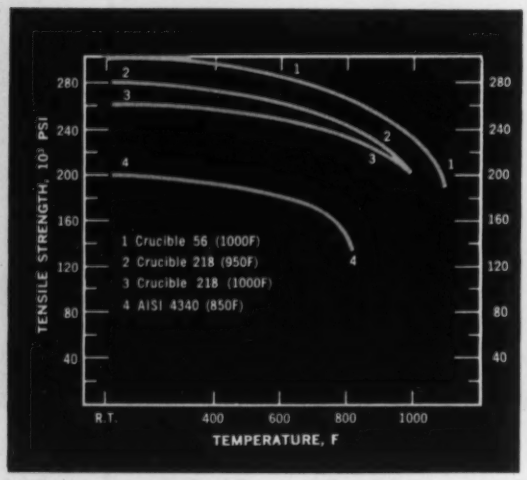


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

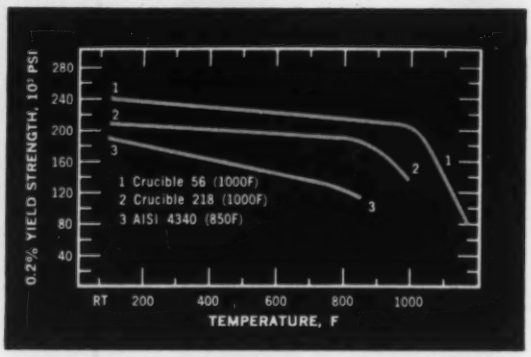


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

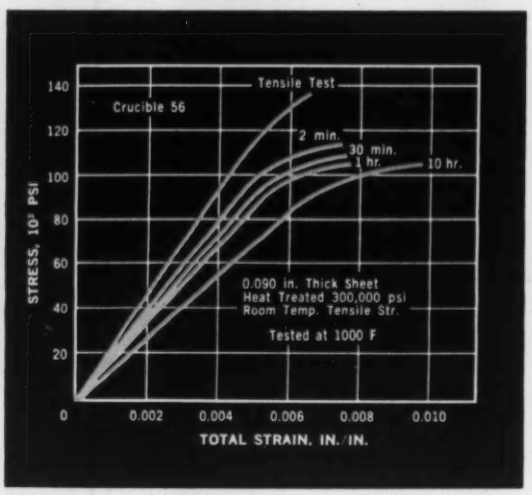


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

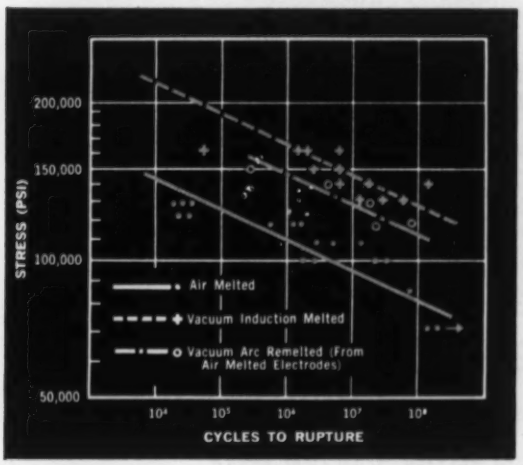
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	H(PPM)	H(PPM)
AM	30	100	< 1
AM+VAR	7	70	< 1
VIM	5	3	< 1
VIM+VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	–	Bal.	1.25	–	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

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Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

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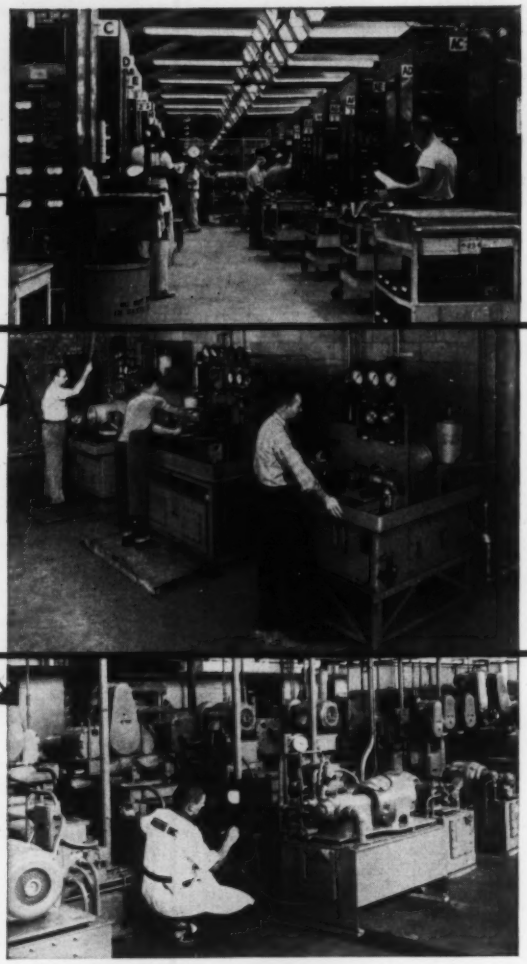

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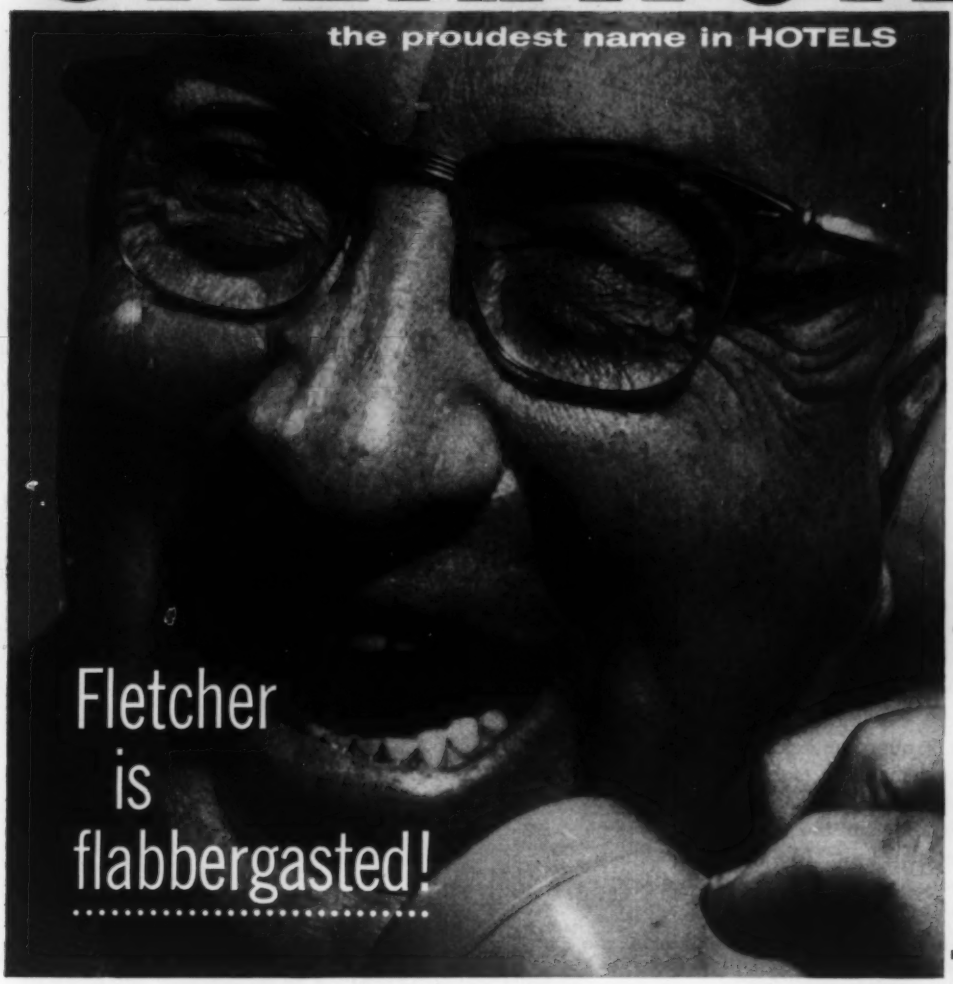

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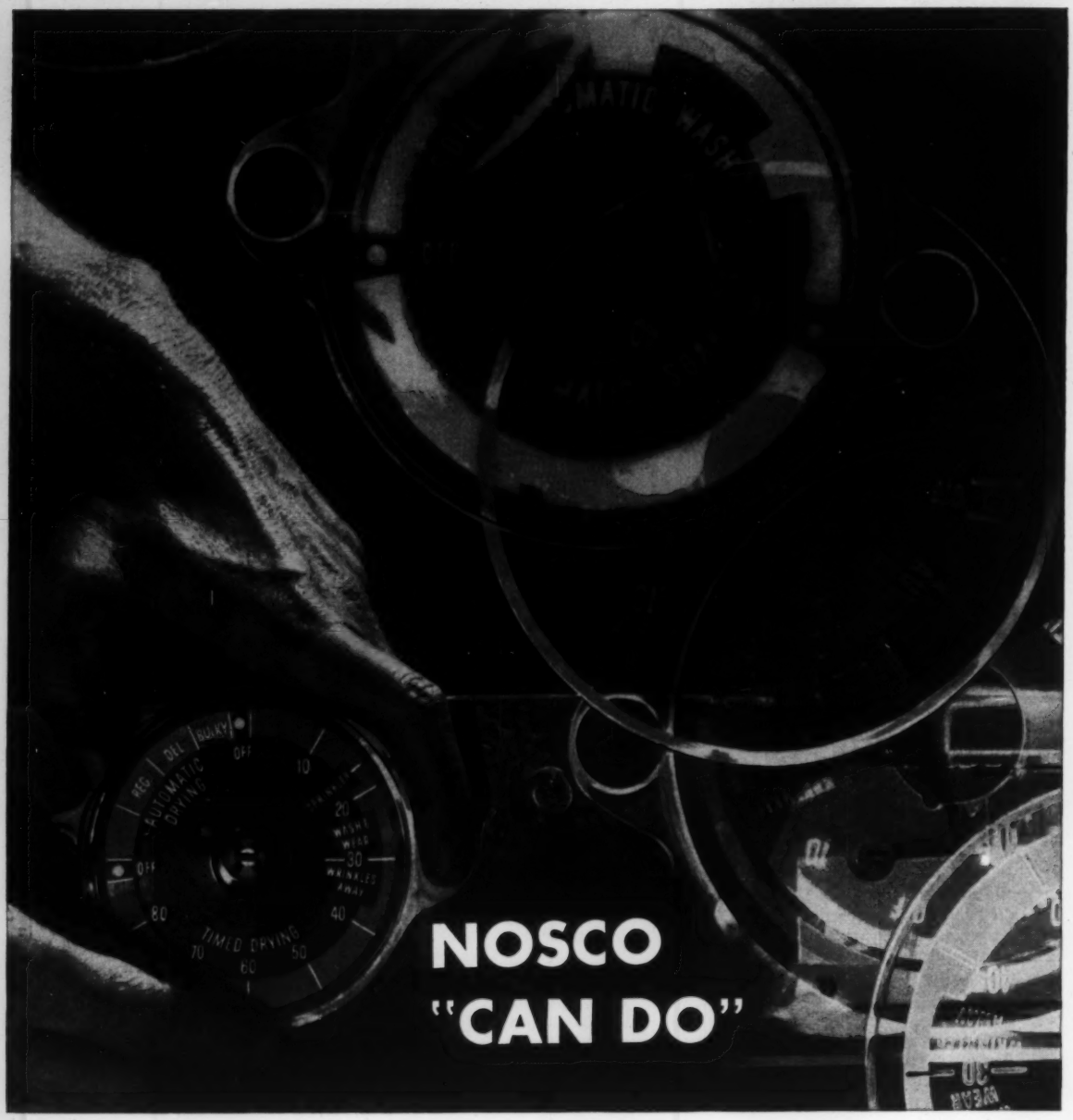

Redesigns decorated plastic dial . . . steps up production rate 30%

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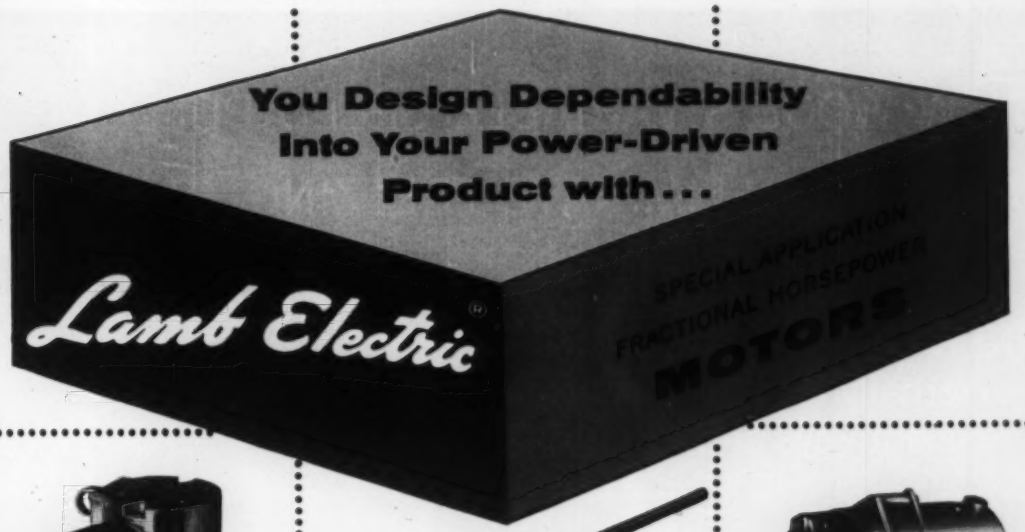
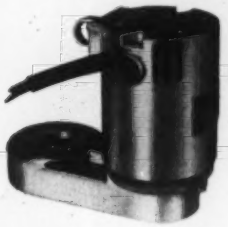
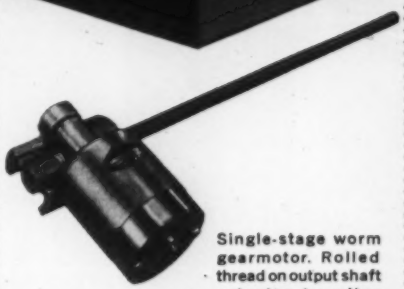


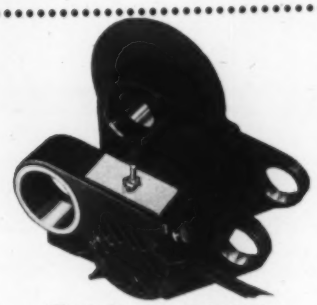


Impact drill motor for putting threaded inserts in concrete. Designed to withstand heavy vibration. Frame 3 11/16 x 1 3/4



Single-stage worm gearmotor. Rolled thread on output shaft actuates traveling nut. Frame 2 7/16 x 1 3/8

Two-stage helical gearmotor with crank on output shaft to operate circuit breaker. Frame 2 7/16 x 1 1/2



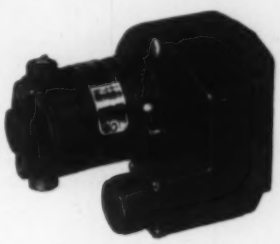
Three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader. Frame 4 3/8 x 2 1/16

Thorough study by our engineering department of your product and its operating conditions is the first step in designing a Lamb Electric motor that will assure required dependability.

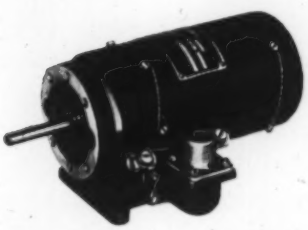
The next step is translating this information into a motor design having the electrical and mechanical characteristics needed for your particular application.

We then custom manufacture the motor on a volume basis to obtain high quality, uniformity and the most favorable cost.

May we discuss these advantages of Lamb Electric motors with you?



24 Volt DC fuel valve actuator incorporates gear train torque-limiting clutch and limit switches. Frame 1 1/8 x 5/16



Totally enclosed fan-cooled 27 volt DC motor for pump drive. Frame 2 x 1 1/2

THE LAMB ELECTRIC COMPANY

Kent, Ohio

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ont.

Heavy duty motor for industrial vacuum cleaners, colloid mills, hoists, etc. Frame 6 x 2 1/2

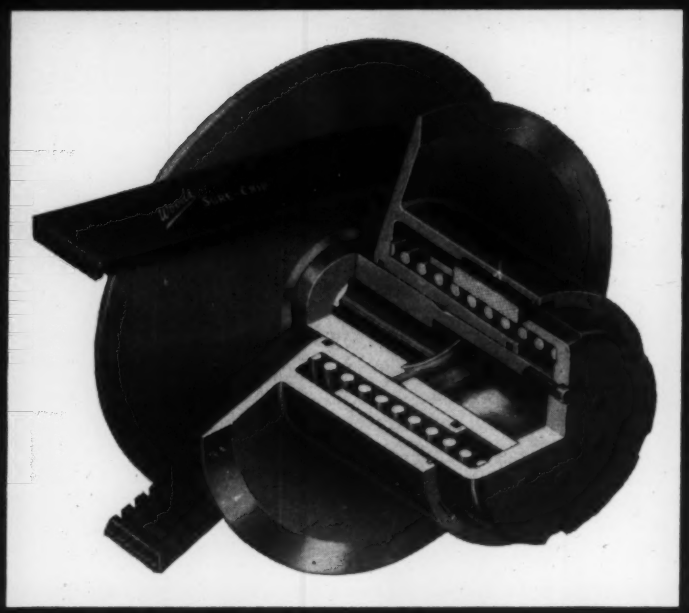
Circle 450 on Page 19

NEW WOOD'S VARIABLE SPEED PULLEYS ACTUALLY ELIMINATE FREEZING, STICKING

NEW
externally located,
resilient keys and

NEW
positive rotational
oil pumping
action give

NEW
freedom from
maintenance
and lubrication



Wood's new "MS" Motion Control Pulleys incorporate an entirely new concept of variable speed pulley design. Revolutionary features not only permit accurate and infinite speed adjustment, but completely eliminate fretting corrosion, freezing and sticking. There is no downtime . . . no periodic running through the speed range and, under normal operating conditions, the oil reservoir requires checking only twice a year. These startling advantages are made possible by two exclusive features . . .

NEW RESILIENT KEYS—There are no keys to obstruct the flow of oil around the bearing surfaces. Power is transmitted through a series of torsionally resilient rubber keys which are located outside the bearing surfaces between the sleeve cap and flange. These long-life, nylon-faced keys not only carry the belt torque but permit oil pumping action and assure even distribution of the load and equal transmission of power by both flanges.

NEW ROTATIONAL PUMPING ACTION—A continuous rotational pumping action of the flange hub on the sleeve completely re-oils the bearing surfaces with each rotation of the pulley. This positive lubrication system has resulted in shorter overall construction and less overhang.

New "MS" pulleys can be used with any type of straight face companion pulley. They are accurately balanced, operate in any position, fit both old and new NEMA frame motors. Get all of the facts. Write for bulletin 4101.

Woods

T. B. WOOD'S SONS COMPANY
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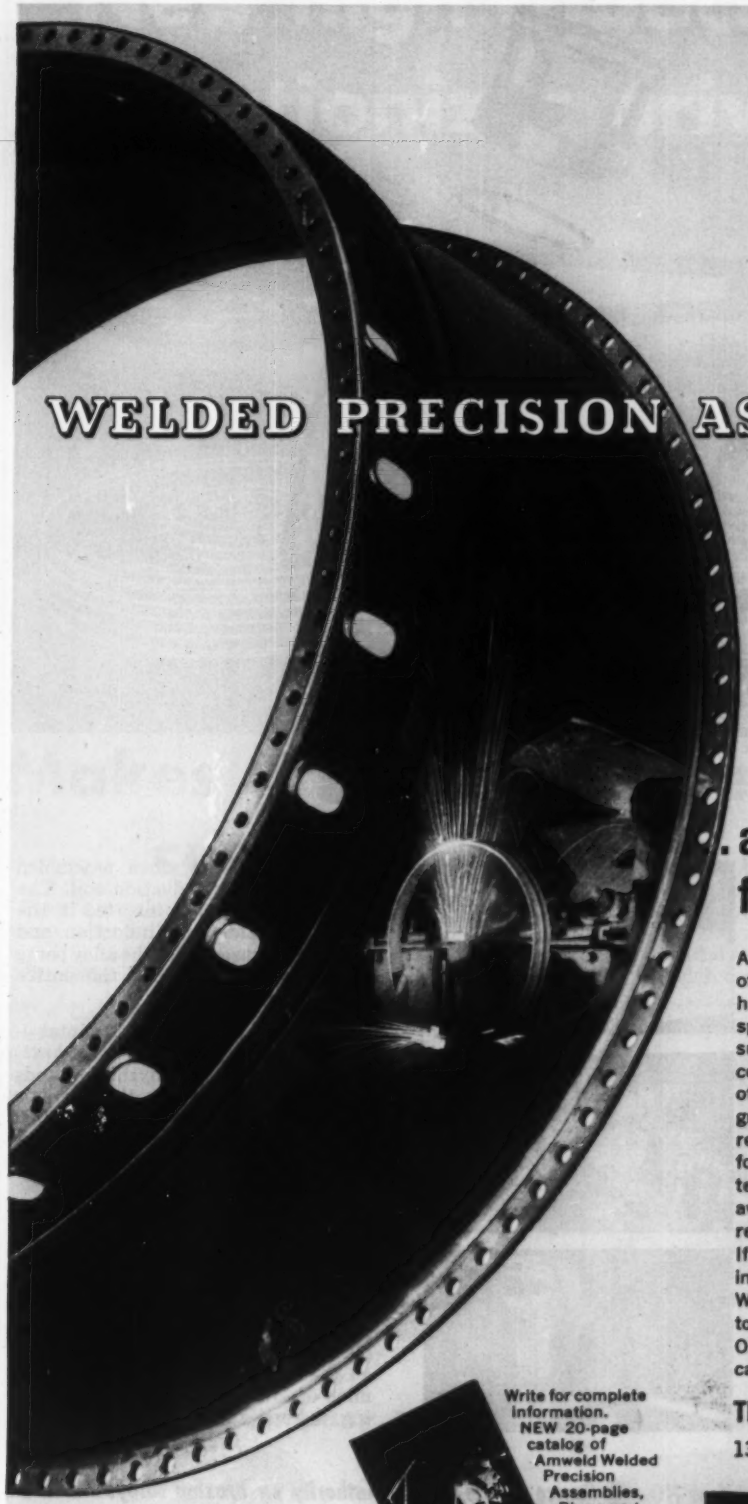
WELDED PRECISION ASSEMBLIES...

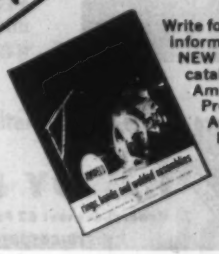


...a major AMWELD® fabricating service

American Welding has produced thousands of complicated welded assemblies, which have satisfactorily met the stringent specifications for aircraft, missiles, submarines and atomic reactors. These components are welded from a wide range of materials, including most stainless grades, titanium, aluminum, and heat-resistant alloys. Amweld's fabricating, forming, and machining facilities, plus testing and research departments, are available on a subcontract or research and development basis.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today.

Our local representative will be happy to call and discuss your requirements.



Write for complete information. NEW 20-page catalog of Amweld Welded Precision Assemblies, Rings and Bands.

The American Welding & Mfg. Co.

130 Dietz Road • Warren, Ohio

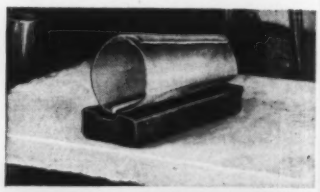
AMERICAN WELDING

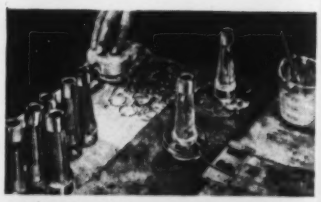
A Brazing Story in Five Parts ...with Handy & Harman EASY-FLO

The Perlman Heat Treating Corp., Westbury, Long Island, brazes aircraft fuel system parts for WEBA, Inc. One of these is a fuel filter screen. It consists of five parts: two stiffeners, a screen and two end fittings, all of 302 stainless steel. All of these parts are joined by EASY-FLO silver brazing, using both induction and hand-torch heating methods.

A novel feature is the induction heating method used to braze the two stiffeners to the screen. It is sort of an "upside-down" method, through an asbestos board and carbon block, on which the screen rests with the EASY-FLO wire preform preplaced. The board and block permit enough passage of heat to melt the alloy to the mesh and stiffeners without excess overflow. Because the alloy won't wet the carbon block, the result is a clean, finished fillet.

The larger, cage-type fitting is HANDY-FLUXED, as is the circular preform of EASY-FLO, then assembled and placed in an induction coil. The smaller end fitting is inserted in the screen, preheated by induction and then torch-brazed, with the alloy being hand-fed. Alloy cost for the entire assembly is ten cents.





The main point here is the adaptability not only of the alloy, but the *brazing method.* Hardly anything stands in the way of brazing that a little ingenuity can't solve, as Perlman Heat Treating has demonstrated. We'll be very glad to bring the full and very beneficial brazing story to your attention. More and more, people with all kinds of metal-joining problems are finding that Handy & Harman silver alloy brazing has most of the answers. Answers that may benefit you.

FIRST, BULLETIN 20 — This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

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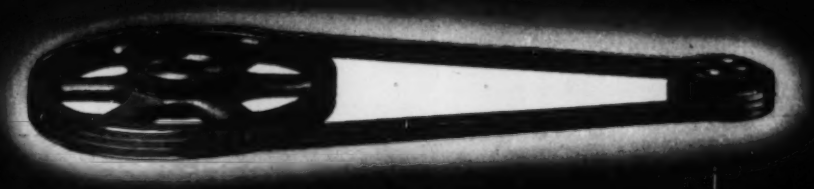
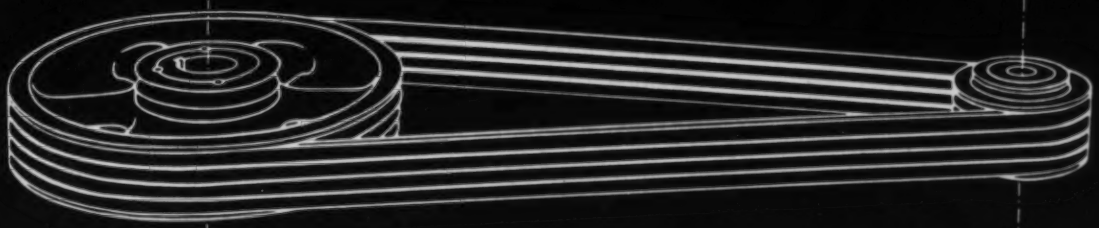
MONTREAL, CANADA

Circle 453 on Page 19

New high capacity V-belt revolutionizes drive design



NEW, COMPACT GATES SUPER HC DRIVE



PRESENT V-BELT DRIVE

Makes drives far more compact... cuts cost as much as 20%

Here is a major advance in the field of power transmission — the fully proved Gates Super HC V-Belt, developed in the world's largest belt-testing laboratories at The Gates Rubber Company.

The Gates Super HC V-Belt makes possible the lowest-cost, lightest-weight, most compact multiple V-belt drive that can be put on any machine! Sheave diameters can be reduced up to 50%, sheave widths 30% to 50%, center distances 20% and more.

On new drives, the cost of a Gates Super HC V-Belt Drive is as much as 20% less than present V-belt drives of the same horsepower capacity.

Learn more about the cost-saving Super HC Drive

For detailed information on the Super HC Drive, contact your nearby Gates distributor or Gates Office for new booklet, *"The Modern Way to Design Multiple V-Belt Drives."*

For utmost space, weight and dollar savings in new drives or drive replacements, specify Gates Super HC V-Belts and Sheaves. Stocks immediately available in principal industrial centers.

How savings multiply with Gates Super HC V-Belt Drive

Cost of a new Gates Super HC V-Belt Drive is as much as 20% less than cost of a drive of comparable horsepower using present V-belts. In addition to the lower cost of the drive itself, further economies are realized on housings and bases — economies in materials, production time, shipping costs.

Shown below are space savings of a typical installation...

	DriveR Sheave Diam.	DriveN Sheave Diam.	Center Distance	No. of belts
Present Drive	7.4"	20.0"	42.9"	4
Super HC Drive	5.3"	14.0"	30.0"	3

The Gates Rubber Company, Denver, Colorado • Gates Rubber of Canada Ltd., Brantford, Ontario

Gates

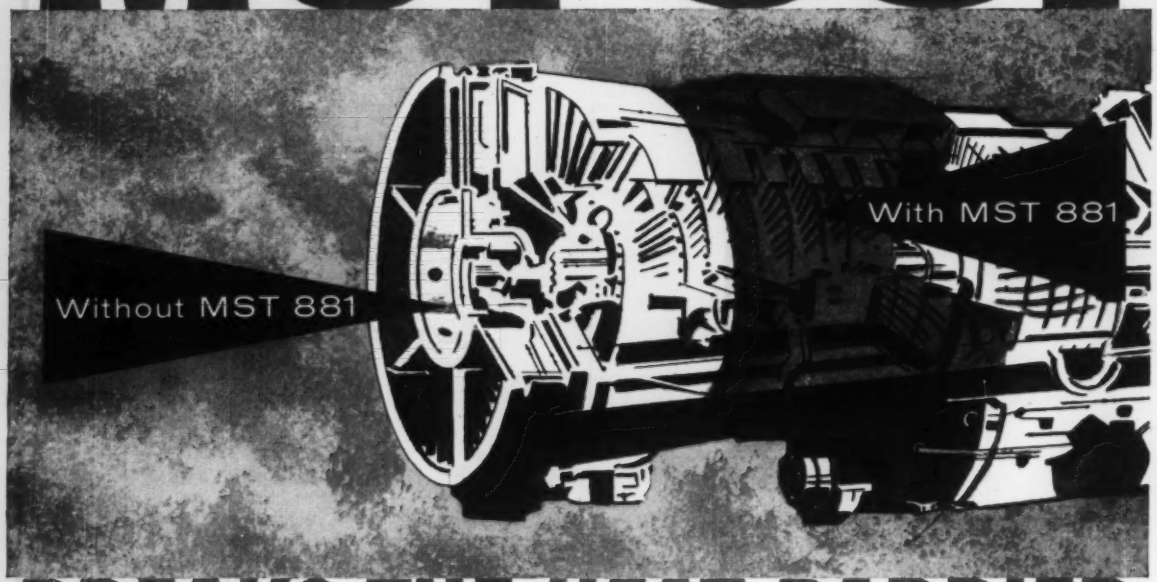
World's Largest Maker of V-Belts

Gates Super HC V-Belt Drives

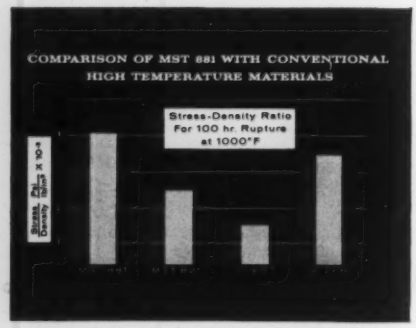
Circle 454 on Page 19

New Mallory-Sharon 1100° Titanium Alloy

MST 881



BREAKS THE HEAT BARRIER



Note high stress/density ratio of MST 881 at 1000° F., compared to MST 821 alloy, 304 and A 286 stainless steels.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

What this means in terms of jet engine construction, for example, is illustrated above. The weight-saving advantages of titanium can now be obtained in additional stages of hot Mach 3 engines through use of MST 881.

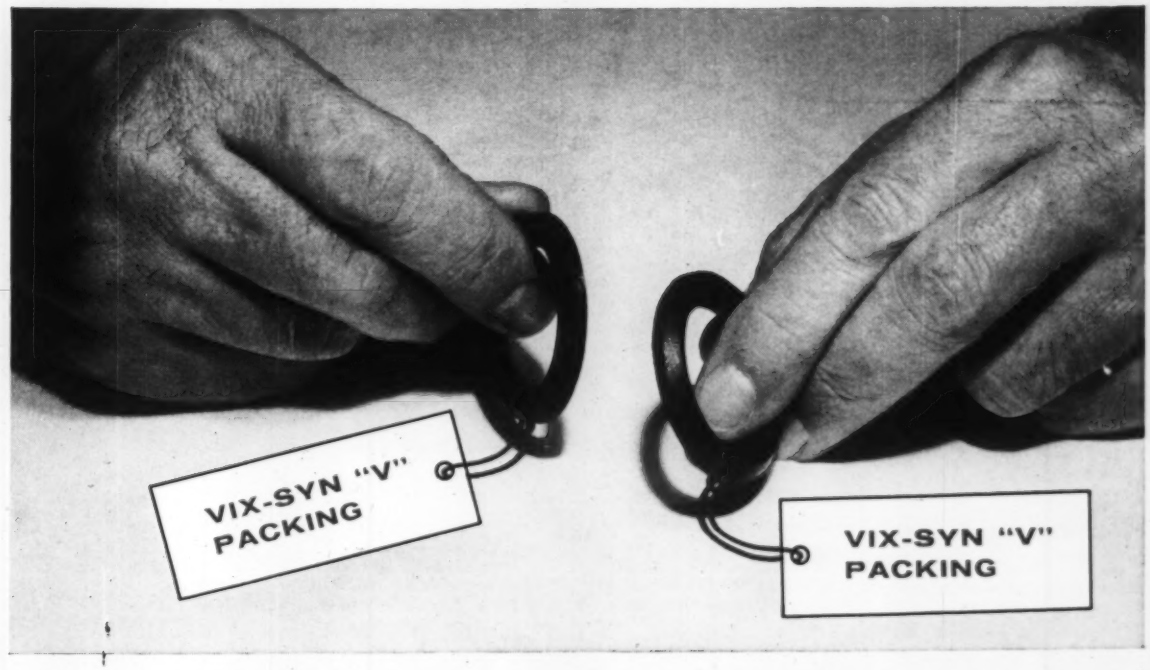
At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has *more than twice the creep strength* of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress at 25,000 psi in 150 hours.

Write today for technical data sheet on MST 881.

MALLORY SHARON

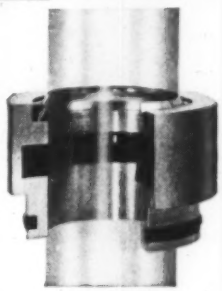
MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Circle 455 on Page 19



Which HOUGHTON "V" ran 6,000,000 strokes?

Exclusive Houghto-Seal Guard



Takes dirt off piston rods
Keeps hydraulic systems clean!

Flexible, knife-sharp, bronze scraper rings, mounted in resilient rubber, remove all dirt and grit from piston rods. Will not score rods yet keeps dirt and grit out of system—easily applied in any rod diameter from ¼ to 6". Ask the Houghton Man for full details.

One of these fabricated rubber "V" packings is brand new. The other ran 6,000,000 strokes in a 1-ton press under test in a user's plant. (It's part of a set of four Houghton VIX-SYN "V's" used to seal the ram on a new line of one and two-ton presses.)

Because of the time involved, the test was stopped at 6,000,000 strokes. But, as you can see, even after this grueling test, the packing showed no wear. In fact, even a close inspection won't tell you which "V" was used in the test. (We had to mark the tag to keep from getting it mixed.) It's the one on the right!

Wear resistance like this is typical of Houghton fabricated VIX-SYN packings. For full information on them write E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa., for folder, "Houghton Fabricated VIX-SYN "V" Packings."

VIX-SYN Fabricated and Homogeneous Rubber and VIM Leather Packings

. . . products of

E. F. HOUGHTON & CO.

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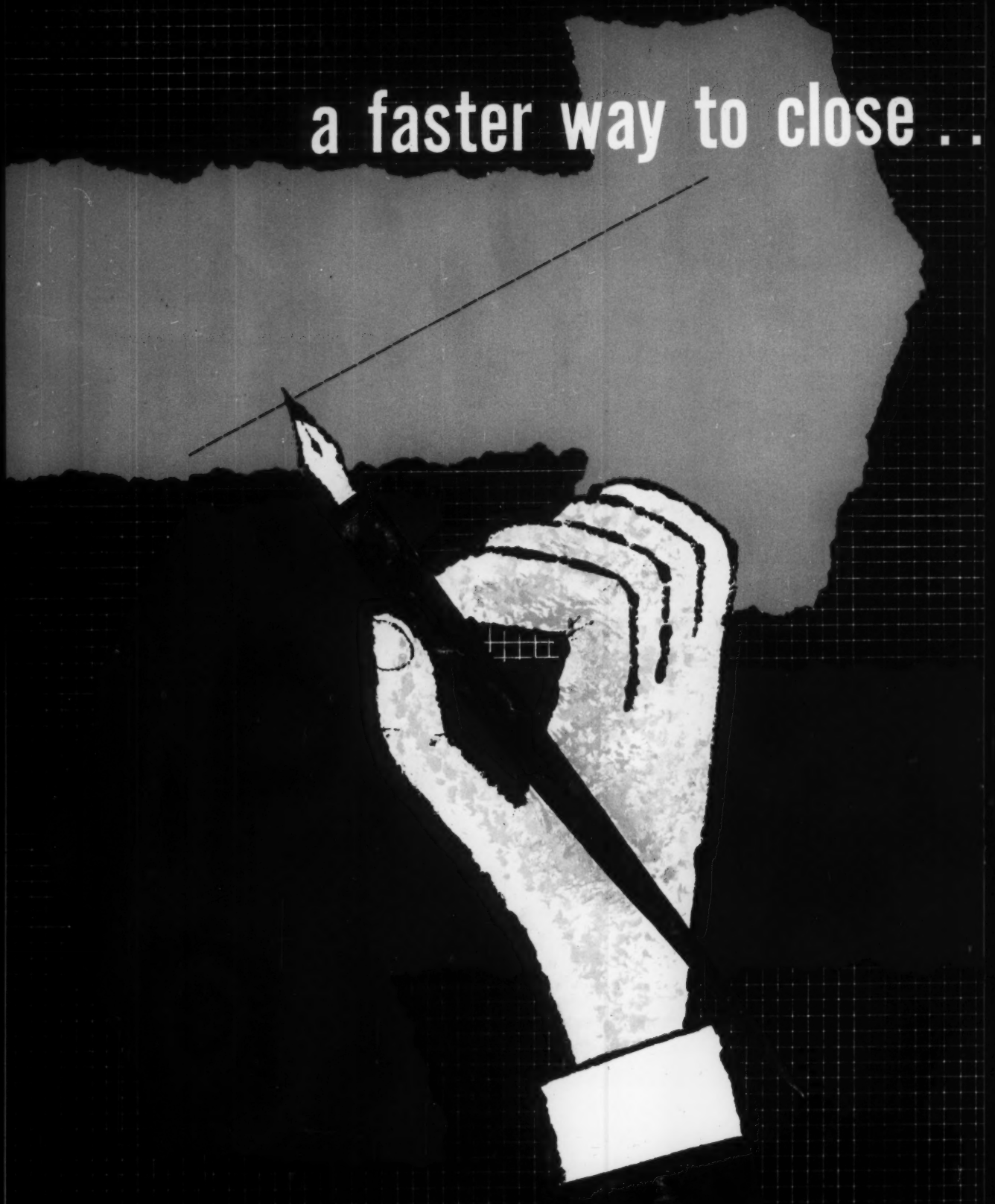
Ready to give you on-the-job service

a faster way to close . .



. . more industrial sales

Top management wants to move more industrial goods at a profit.

What's the answer? Better marketing. A *faster* way to close more industrial sales.

That is why so many purely industrial companies are turning to a proved mass selling technique, to help their salesmen move more goods within industry . . . improved *two-way communication.*

Communication *from* your market—finding out what industry wants—where the most promising markets are—what advantages motivate the buyer.

Communication *to* your market—helping to raise the productivity of the salesforce . . . make multiple sales contacts among industry's complicated group buying patterns . . . make selling more profitable.

The answers to many of marketing's questions are already available. You'll find practical, helpful information in FOUNDRY's "Foundry Industry Marketing Guide"; STEEL magazine's new book "Metalworking Markets in the U.S."; MACHINE DESIGN's "Geographical Analysis of the Original Equipment Market"; AUTOMATION's "Confidential File"; N.E.D.'s "How to Get Industrial Buying Action".

Better readership in the right places will give you improved communication *to* your market. Penton's selective industrial publications have won an important place on the marketing teams of many leading companies for just this reason. They deliver the top readership of the most important buying teams in their markets.

The Penton representative who calls on you is your partner in marketing. He can show you effective, proved ways of strengthening your market communications—to help achieve top management's goal . . . moving more goods within industry, at a better profit.

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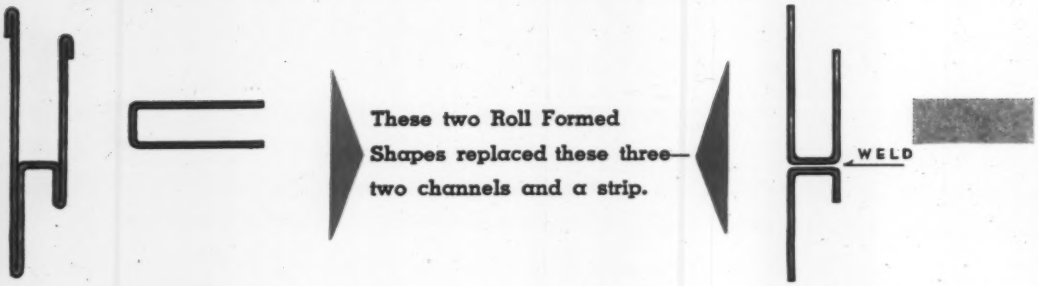
AUTOMATION / FOUNDRY / MACHINE DESIGN / NEW EQUIPMENT DIGEST / STEEL

2 parts replace 3 and reduce assembly costs



IN DESIGN

Product design created production problems. Solid strip was difficult to obtain. It was replaced by a Roll Formed U channel which weighs 55 % less. Many cut hands resulted from old channels. Hemmed edges on special Roll Formed shape eliminated this hazard. Dimensions are identical and structural strength is improved. Over-all appearance is decidedly improved.

IN PRODUCTION

Old assembly required 10 welds — 6 on channels and 4 in assembly. Roll Formed shape requires just 4 tack welds in assembly. One supplier and just two components permit deliveries keyed to production needs. Hemmed edges on H shapes eliminated cut hands on assembly line.

IN PURCHASING

Bookkeeping reduced by elimination of one item. Deliveries on time and keyed to production needs. Total costs on purchased items and assembly time were drastically reduced. Shipping weight reduced and net profit on the completed item was increased.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered burr-free to match your production schedule.

CAN ROLL FORMED HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017 today.

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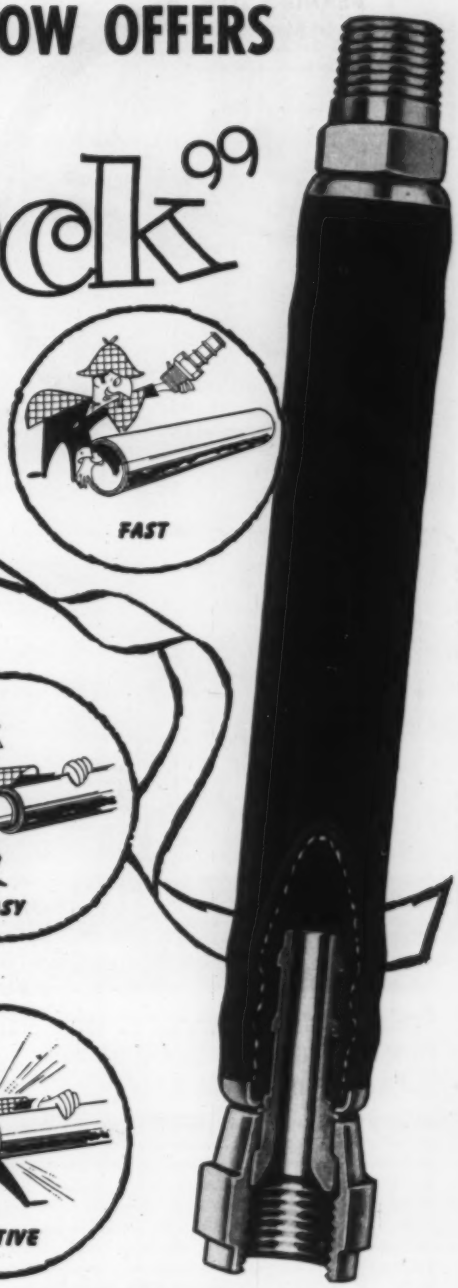
Circle 458 on Page 19

ALEMITE SURGEPRUF® NOW OFFERS

new

"Shur-Lock"

LOW-PRESSURE HYDRAULIC HOSE AND COUPLINGS



An important addition to Surgepruf High and Medium-High Pressure Line

Now, low-pressure applications can be serviced with reusable couplings and hose using Surgepruf's *Shur-Lock* – giving you the same high quality and reliable service that has made Surgepruf medium-high and high-pressure hose accepted nation-wide by industry!

Rugged, precision-matched couplings! Impervious to corrosion. Long ferrules with deep grasping ridges assure extra-long, leak-proof grip. Reusable again and again!

Tough rubber-covered hose! Seamless Buna-N inner tube, reinforced with fabric braid. Does not require skiving for assembly with Shur-Lock couplings. Designed for use over temperature range of −40° to +275°.

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- Compressors, Portable Air Tools, etc.
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Please send me a free copy of your Surgepruf Shur-Lock catalog.

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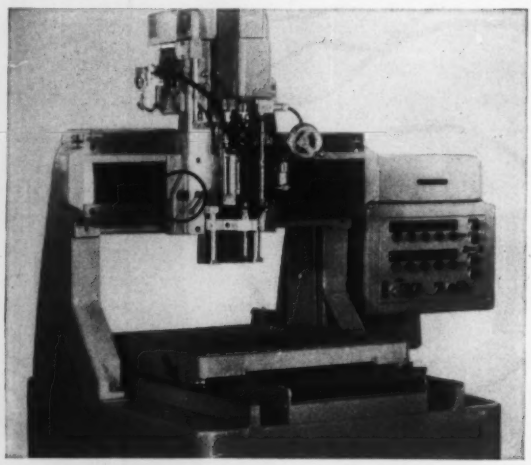
Circle 459 on Page 19

BEARING TIPS
by McGill

McGILL sealed CAMROL® bearings protect roller follower efficiency — prelubricated to reduce maintenance

Sealed SCF series bearings add protection from contamination to the extra performance advantages of McGill CAMROL cam followers. Specially treated labyrinth seals at the roller ends keep out moisture, dirt, chips, etc. All exposed surfaces are treated to provide a corrosion resistant black ferrous oxide finish.

The sealed construction with a channeled grease reservoir in the outer race bore eliminates need for frequent relubrication. Maintenance is reduced and can be eliminated in inaccessible mountings. Specify standard bearings and avoid building up followers with extra seals.



Sealed CAMROL bearings as table and crosshead rollers in tape-controlled Hillyer drilling machine

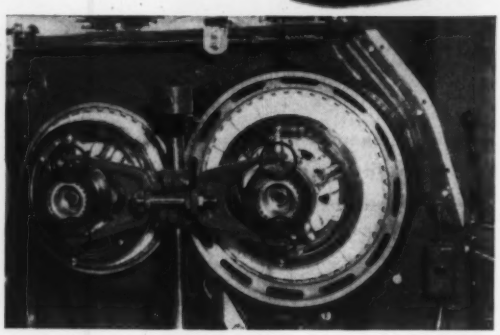
CAMROL bearings provide smooth, accurate motion as load carrying rollers for table and crosshead motion of this tape-controlled, precision drilling machine manufactured by HILLYER CORPORATION. Use of these bearings has simplified construction and improved accuracy. They have eliminated the manufacture of shaft and retainer assemblies and increased load capacities. The corrosion resistant finish has also eliminated the need for plating bearings. Ball bearings formerly used cracked under the same loads. Operating speeds are 400 RPM and loads are 2000 pounds. The bearings are prelubricated and sealed to keep maintenance at a minimum.

Sealed CAMROL bearings replace bronze rings in shovel clutches

UNIT CRANE & SHOVEL CORPORATION is using SCF SEALED CAMROL bearings in clutch shifter yokes in their ½ and ¾ yard power cranes and shovels and Model 360 MARINER 30-ton cranes. Shown is a closeup of two of the five clutches which control the hoist drum and the hold drum and various actions of the machines. The bronze collars formerly used were higher in initial cost than the CAMROL bearings. Their use also required considerable machining and the addition of component parts such as bolts, spacers, etc.

The CAMROL bearings in this application promise better, more accurate control than the bronze shifter rings which tend to become "sloppy" with wear.

The integral seal feature of the bearings protects their performance under field conditions and reduces relubrication requirements.



engineered electrical products

McGILL®

precision needle roller bearings

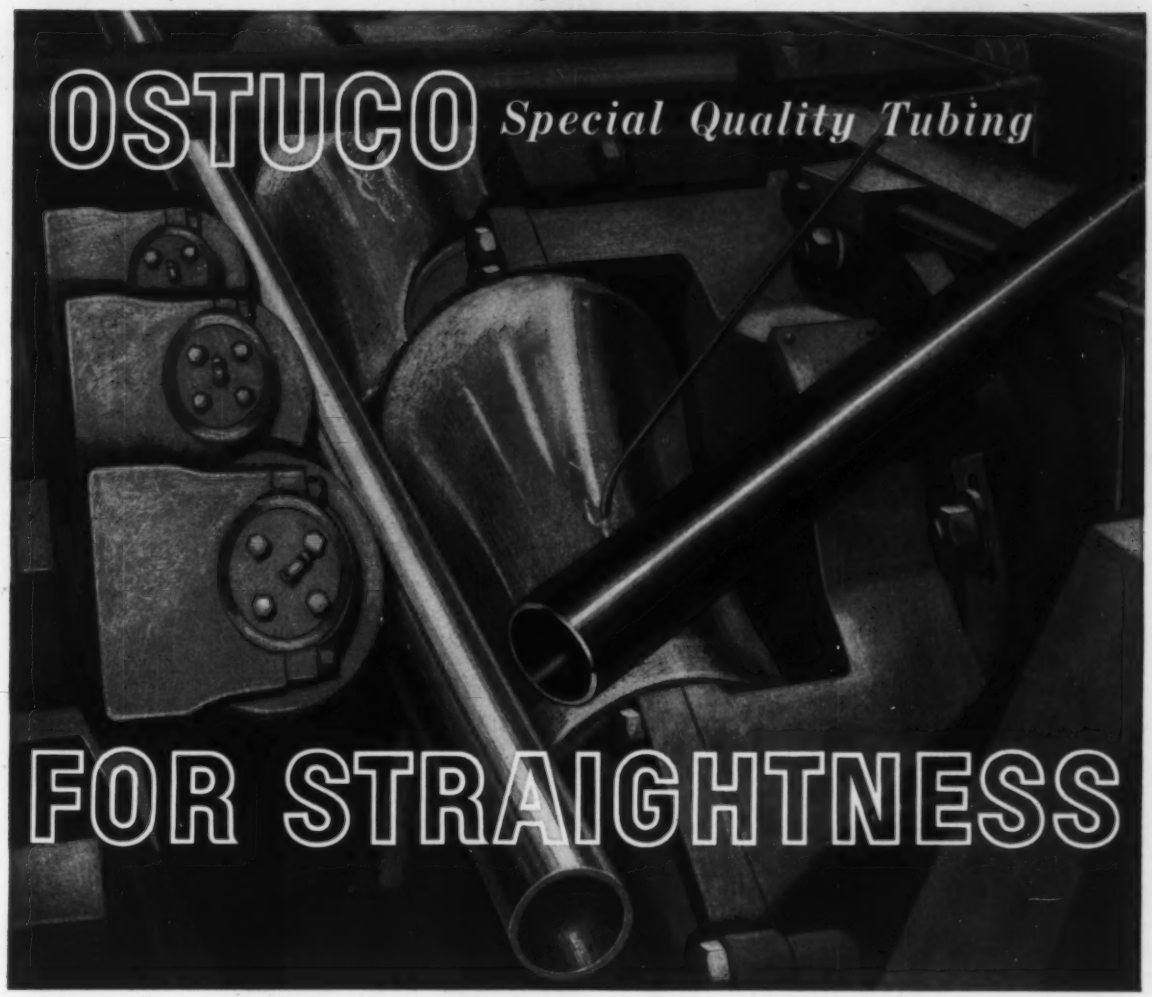
SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 460 on Page 19

Helicopter Manufacturer Specifies



Straightening Ostuco Special Quality Tubing to extremely close limits at Shelby mill.

"Our specifications for seamless steel tubing used in rotor drive shafts are tough to meet. In addition to stringent O.D., wall and concentricity tolerances, we require *special straightness* — tube after tube, shipment after shipment.

"Ohio Special Quality Tubing surpasses any other tubing we have ever used. We know this to be fact. Scrap and rejects are at a new low, inspection OK's and savings on this part are at a new high."

This actual case history may parallel your own product problems. For with Ohio Special Quality Tubing it's only the *quality that's special.* For further information contact our nearest sales office, listed in the Yellow Pages, or the plant at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-9011

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OHIO SEAMLESS TUBE DIVISION

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Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

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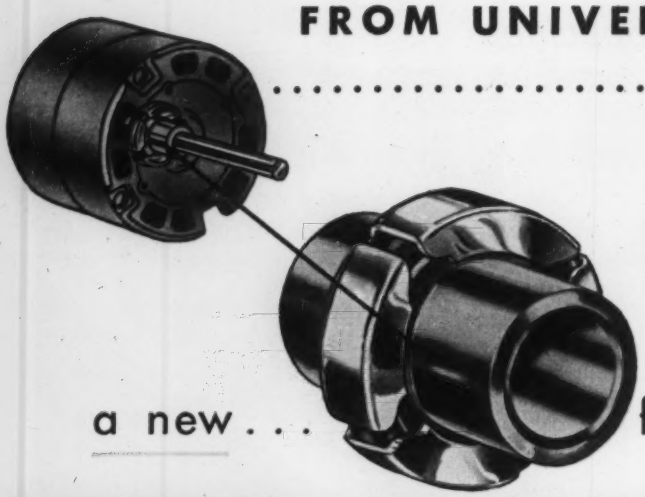
FROM UNIVERSAL ELECTRIC



THE UNIVERSAL BEARING*

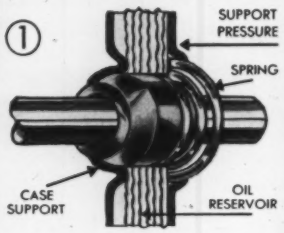
a new . . . free aligning bearing

*PATENT APPLIED FOR

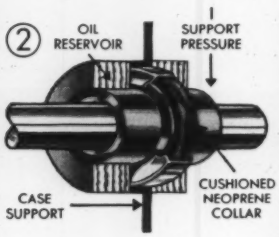
A new revolutionary bearing assembly, the **Universal Bearing,** that promises to eliminate fractional hp motor bearing problems has been designed and is now a feature of UNIVERSAL ELECTRIC motors. The new **Universal Bearing** does not rely on spring tension to aid its alignment but utilizes only the shaft itself. This is accomplished by moving the axis of support from the end of the bearing to the center . . . the ideal location.

Flexibility and rigidity of bearing support and bearing are of primary importance, particularly in fractional hp motors. The design of the **Universal Bearing** insures continuous and positive alignment to the shaft at all times. A neoprene collar, which is flexible, provides a perfect and firm fit between bearing and bearing support surface. The **Universal Bearing** is inherently in balance . . . and cannot get out of either alignment or balance. It is as firm as a rigid bearing; more flexible than a self aligning bearing.

The **Universal Bearing** Assembly provides longer bearing life, better lubrication and an easier starting motor that runs without a whisper of sound. This is the first major bearing improvement since UNIVERSAL introduced the coil spring bearing retainer in 1944.



In the conventional bearing assembly, the case support places pressure on the end of the bearing rather than in the center. A spring is utilized to allow the bearing to accommodate shaft misalignment. The spring, however, does not provide *even* tension around the end surface of the bearing on all loads. When at rest, the weight of the shaft pulls the bearing out of line and the spring, because of uneven tension, tends to *resist* rather than help the bearing to adjust; actually holds the bearing in misalignment. This results in a bearing not perfectly aligned with the shaft on all loads and causes wear on shaft and bearing . . . sometimes actual seizure and motor failure. At the very least, this condition results in a hard starting or a noisy motor.



The new **Universal Bearing** is so designed that support pressure is on the center of the bearing, rather than on the end. This eliminates the uneven tension common in the spring and permits adjustment of the axis position to *true* alignment. The bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. A neoprene collar is used around the outside surface of the bearing to accommodate manufacturing tolerances. Small metal clips are fitted around the outside surface to confine the neoprene collar and allow a free sliding movement along the bearing support surface. The neoprene collar expands or contracts within the metal clips to afford a perfect mating surface.

50

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

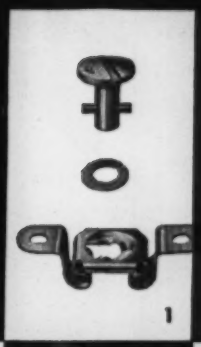
Circle 462 on Page 19

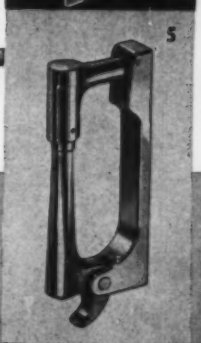
specialists in fasteners for industry

speed · versatility · positive performance

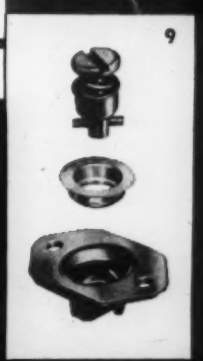
Outstanding creative engineering at Camloc has produced a variety of fastening devices. For access panels, doors, other closures, for simplified replacement of components and sub-assemblies. There are other fastening devices, designed for a variety of specialized applications, all of them retaining the three important features that characterize all Camloc products . . . speed, versatility and positive performance.

CAMLOC





1. SF fastener for thin materials
2. 2600 Series Quarter-Turn
3. Miniature Toggle Tension Latch
4. 91F Heavy Duty Quarter-Turn
5. Electronic Chassis Latch
6. Push Button Latch
7. 28F Series Quarter-Turn
8. 7C Harness Clamp
9. 4002 Series Quarter-Turn
10. SPF (Stressed Panel Fastener)



JUST OFF THE PRESS... The new Condensed Catalog No. 59. Write for your free copy now.

CAMLOC FASTENER CORPORATION • 37 SPRING VALLEY RD., PARAMUS, N. J. • LOS ANGELES, CALIF. • FT. WORTH, TEXAS

Baffling is the art of filtration...

That's why good engineers throughout industry make use of Dollinger's 35 year experience in making dry type filters for practically every known application. Quite possibly, the problem you have today was solved years ago by Dollinger research. You owe it to yourself, and your company, to find out what Dollinger knows before spending more time developing your own solution.

We don't claim to have "all the answers" on filtration, only a few engineering "short-cuts" that will certainly save you many experimental hours.

Why not investigate Dollinger's facilities, experience, and personnel. Start by writing for brief composite catalog. It describes both standard and special Dollinger filters and their applications.

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STAYNEW FILTERS

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LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

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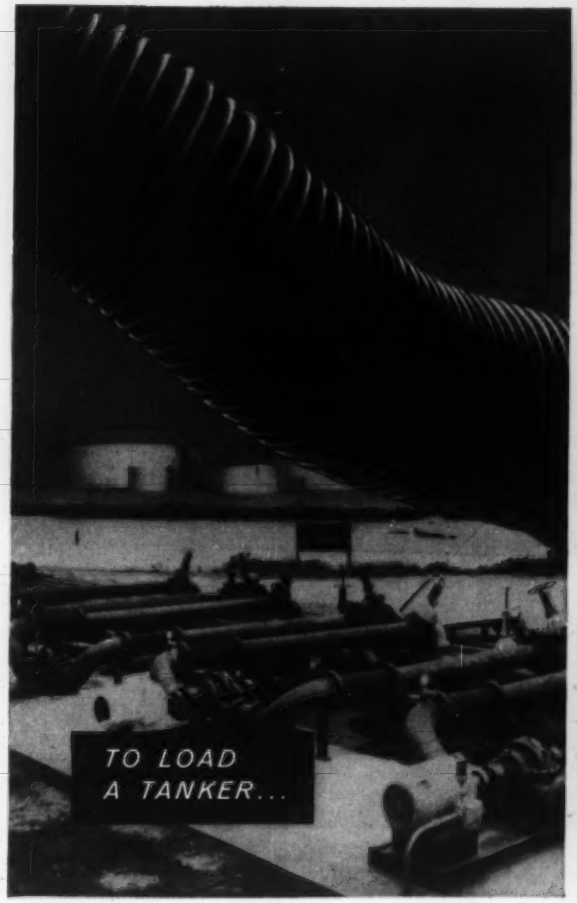

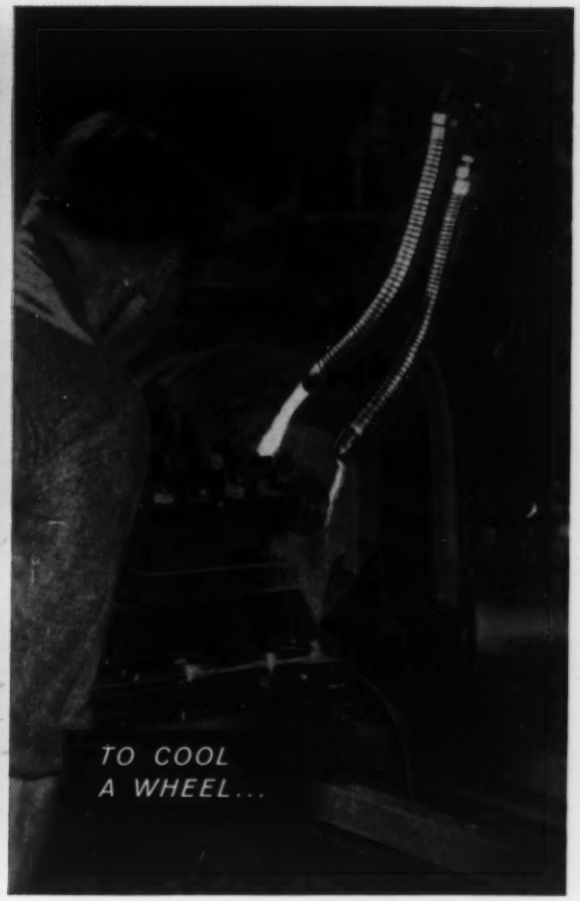

METAL HOSE... in the broadest line of sizes and materials for lower cost, faster delivery

Whatever the medium you have to convey, or the pressure, temperature, motion and corrosive factors to be considered . . . FLEXONICS is more fully capable of supplying the size (from 3/16" to 24" I.D.), construction and material of hose you need. This can mean important savings in cost . . . in time. And, if your requirements necessitate special engineering, FLEXONICS is the source for help.

Write for the complete FLEXONICS Metal Hose Design Guide. Whatever your field, you will find it valuable reference.

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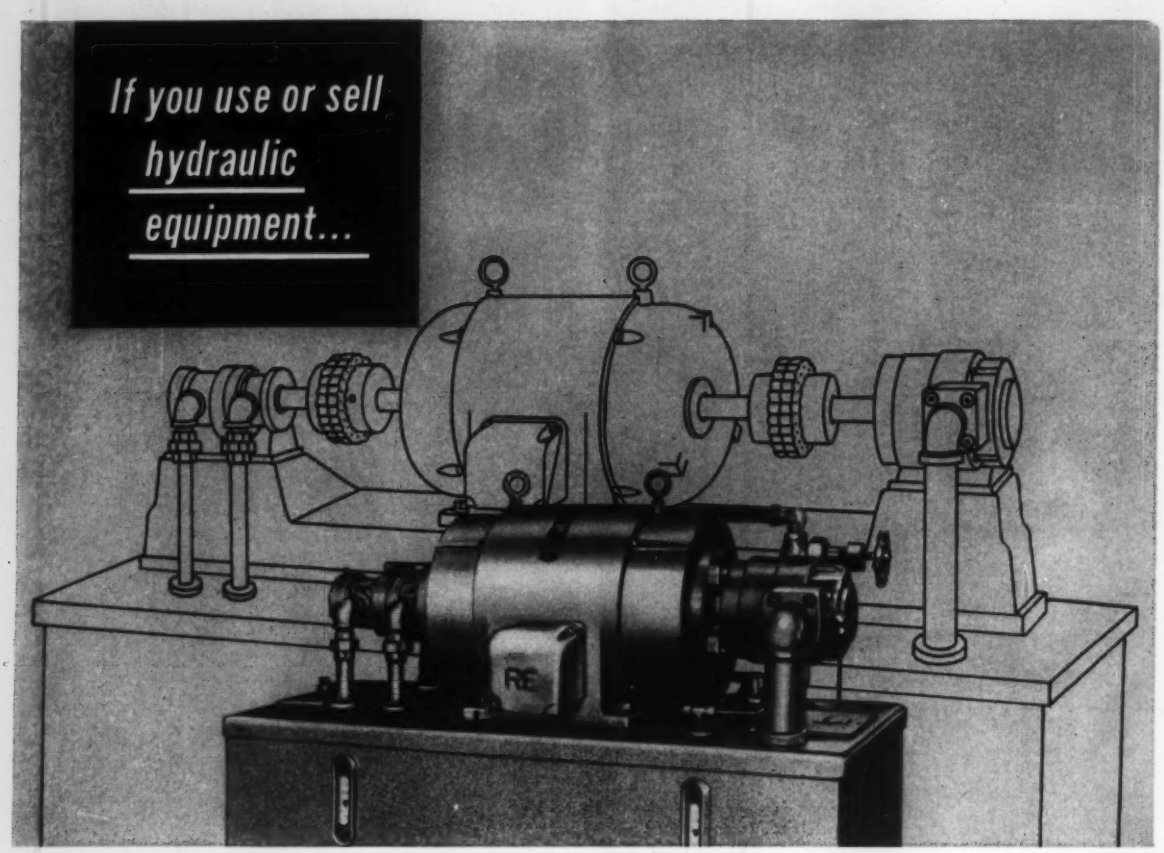


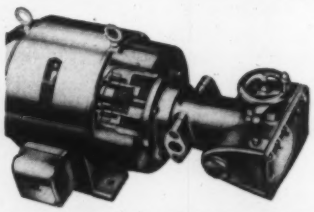
...specify REULAND spline-coupled pump mount motors

...CUT SPACE NEEDS ALMOST 50%...AVAILABLE *NOW* IN ½ H.P. THROUGH 50 H.P.!

Pump and motor become *one* with the new Reuland spline-coupled hydraulic pump hook-up. The pump shaft is connected directly to the motor's shaft *inside the motor*. Flexible couplings are eliminated... pump mount platforms are eliminated... and the tank length can be reduced because almost 50% less mounting area is required. Compact appearance is beautiful.

SPEEDY INSTALLATION

Pump-to-motor hook-up is merely a matter of seconds. All you do is slip the spline coupling onto the pump shaft...and attach the pump to the endbell. This spline coupling is supplied with the motor and is precision mated for each make of pump. There's no time wasted tinkering around... takes only a fraction of the ordinary time.



PRECISION ALIGNMENT

Alignment is perfect *automatically* whether the installation is made out in the field or on the production line. This permits even unskilled workmen to handle this simple task without error. Also, by hooking the pump up at the point of bearing support, within the motor, vibration is reduced to a new minimum. Operation is smooth, quiet.

COSTS LESS...SAVES INSTALLATION LABOR... FITS ALL PUMPS...FILLS ALL POWER NEEDS—

½-50 H.P. The Reuland spline-coupled unit is priced lower than a conventional set-up ...saves you extra money by reducing installation costs. What's more, we can supply it to fit any make of pump you may be using...and to your *exact* power needs, from ½ h.p. through 50 h.p. So sure are we that it will be of help to you, we are offering to engineer a demonstration unit to your equipment, without the slightest obligation. These units are our best salesmen.

Our New General Catalog Will Come In Handy—Sent Free on Request.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY

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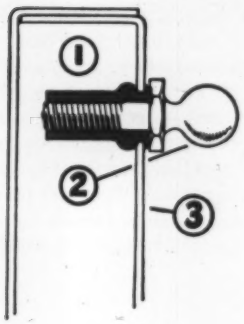
Circle 466 on Page 19

B.F.Goodrich B. F. Goodrich Rivnuts® solve 3 fastening problems at once!

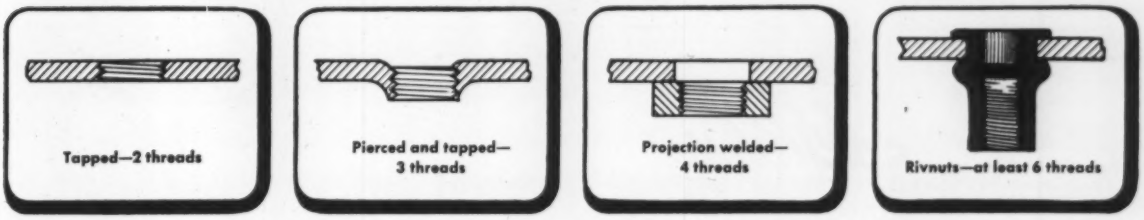


A RIVET WAS NEEDED for doors of metal cabinets that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment and 3) could be installed after enameling. B. F. Goodrich Rivnuts proved the perfect answer.

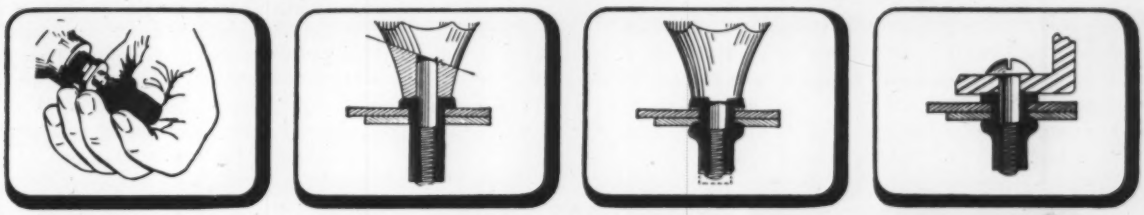
A flat-head Rivnut is inserted in the sheet metal door. Working from one side, one man can upset Rivnuts in seconds with easy-to-operate heading tool. Bulge formed in Rivnut shank grips the metal tightly. The knob of the catch is then threaded into the clean, still-intact Rivnut threads. Rivnuts are installed after enameling—without marring the finish.

B. F. Goodrich Rivnuts, the only one-piece blind rivets with threads, save many man-hours on the job. If you have a fastening problem, why not put it up to B. F. Goodrich engineers?

Compare these 4 methods of putting screw threads in thin sheet metal:



Rivnuts provide at least 6 clean threads in one simple operation!



1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2 Rivnut is inserted—head firmly against work—tool at right angles to work.

3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

SEND NOW FOR FREE RIVNUTS DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, gives proved applications. Write for your free copy today to *B.F.Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MD-29, Akron, Ohio.*

B.F.Goodrich *aviation products*

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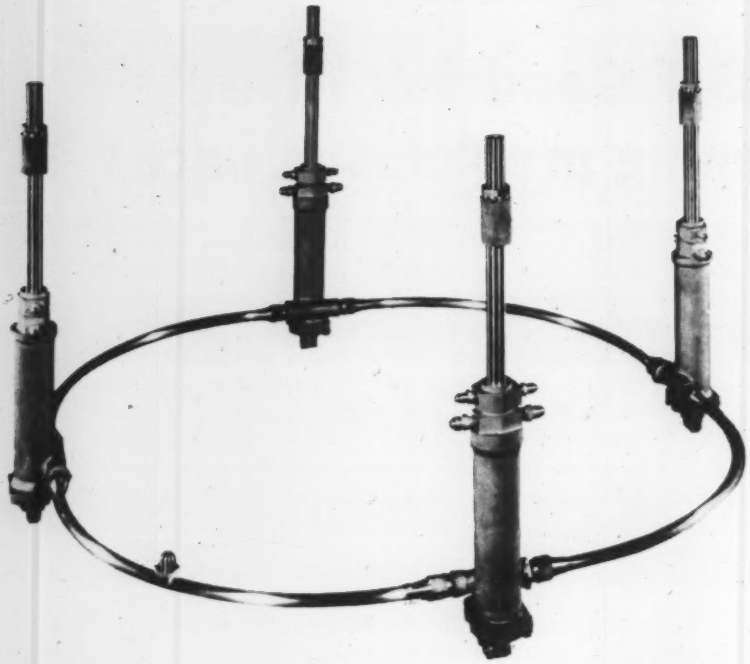
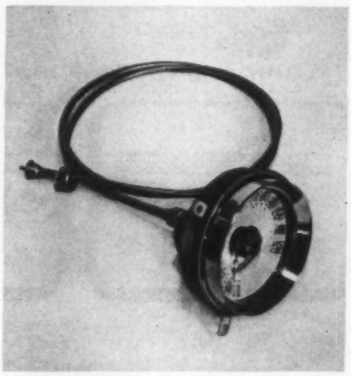


JET AFTERBURNER CONTROLS incorporate four S.S.White Remote Control Flexible Shafts to make possible dependable coordinated operation of engine-thrust spoiler-thrust reverser combinations. Shafts synchronize the system to permit multipoint installation and smooth, even application of power. The actuator has operated dependably at ambient temperatures up to 1000°F. For any remote control application consider the advantages of S.S.White Flexible Shafts.

S.S.White

POWER AND CONTROL IDEAS FOR ENGINEERS

Tips on Better Designing with Flexible Shafts



AUTOMOBILE SPEEDOMETER RELIABILITY is taken for granted thanks to dependable operation provided by S.S.White Flexible Shafts. Driven through a geared take-off from the transmission, flexible shafts stand up under the most severe operating conditions in all weather and temperatures.

ALIGNMENT IS NO PROBLEM on this pump shaft drive pulley device used for regulating tension on a V-belt drive. An S.S.White Flexible Coupling Shaft is incorporated in the gear pump drive which delivers oil under 400 psi to a hydraulic speed selector in an automatic gear shifting device. S.S.White Coupling Shafts—short pieces of flexible shafting without companion casings—meet many power drive and remote control needs.

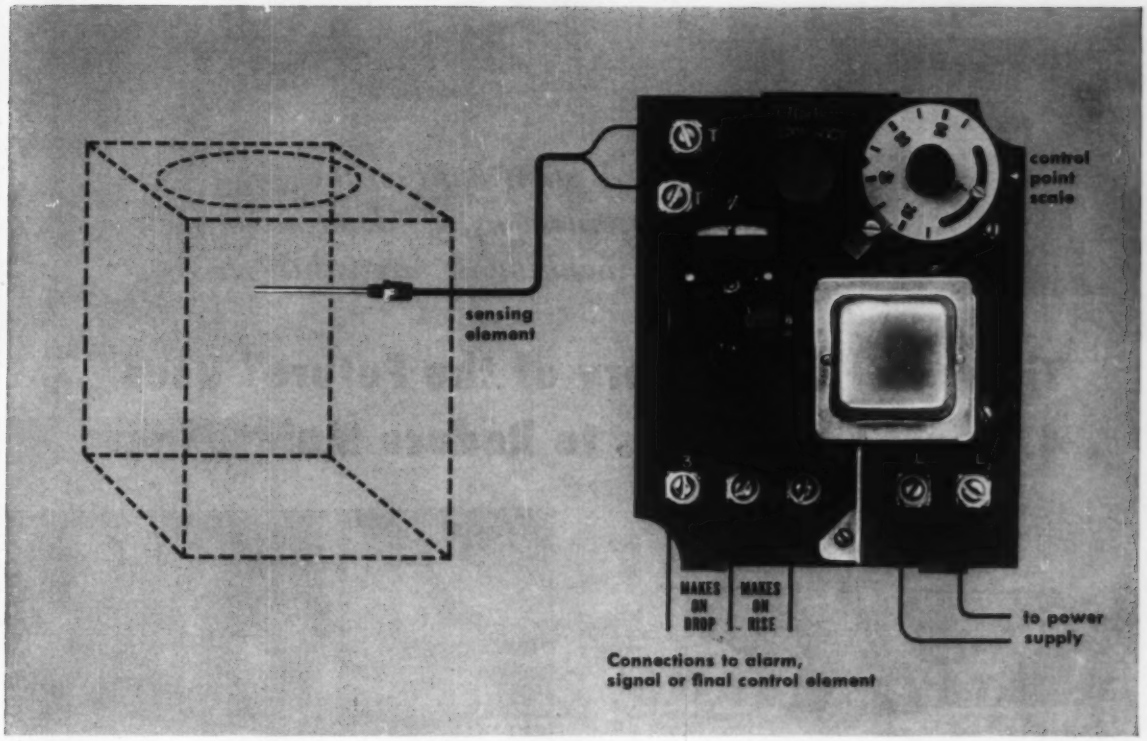
REFERENCE MATERIAL FOR ENGINEERS. For complete information on flexible shafts and how to select and apply them, write for Bulletin 5601.

STANDARD SHAFTS. Standard "off-the-shelf" flexible shafts are a big convenience in design. For full details write for Bulletin 5608.

S.S.White — FIRST NAME IN FLEXIBLE SHAFTS

S.S.WHITE INDUSTRIAL DIVISION, 10 East 40th Street, New York 16, New York
Western Office: 1839 West Pico Blvd., Los Angeles, Calif. (Dept. A)

Circle 468 on Page 19



Now . . . precise, low-cost temperature control . . . with new VERSA-TRAN®

VERSA-TRAN is an exciting new development in low-cost controls—an entirely different kind of amplifier relay that works with specially designed sensors to control temperature with the accuracy usually found only in more complex instruments.

VERSA-TRAN relays are fully transistorized, vibration resistant, and designed for long, dependable service in even the most demanding applications. They control liquid or air temperatures in overlapping ranges from –60° to 500° F, and surface temperatures from –60° to 200° F.

Wiring between the relay and the sensor can be ordinary 18 gauge, 2-conductor cable. The relay is available for flush mounting, surface mounting, or for mounting in most electrical enclosures. It has been accepted for UL listing. VERSA-TRAN gives you flexibility and sensitivity at surprisingly low cost . . . is already solving many difficult control problems.

Your nearby Honeywell field engineer can help you profitably apply new VERSA-TRAN transistorized controls. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL *First in Control*

A plant built on the philosophy of "don't accept anything at face value"...

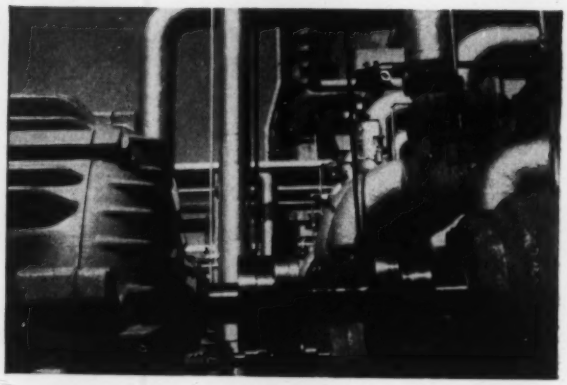
Tidewater's "Refinery of the Future" Uses 471 Fast's Couplings to Reduce Maintenance

IN PLANNING Tidewater's Delaware Refinery, all equipment purchases were examined from every angle . . . capital investment, manpower, maintenance and reliability. Fast's Self-Aligning Couplings were used throughout because they met Tidewater's exacting demands.

Tidewater's equipment design policies were established by survey teams that visited refineries all over the country. They carefully appraised each plant and asked operators what improvements they would make and what features they would retain if they were to redesign their drives.

In 471 applications at this refinery, Fast's Couplings guarantee mechanical flexibility that eliminates costly shutdowns and expensive shaft replacements. Fast's have the reputation of frequently outlasting the equipment they connect. This means savings in maintenance and down-time . . . in addition to protecting costly equipment against errors of alignment.

Nearly 40 years of coupling experience qualifies Koppers to solve *your* coupling problem. Write today for full details to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 5602 Scott Street, Baltimore 3, Md.



Fast's Couplings give dependable, trouble-free service throughout Tidewater's entire production facilities.

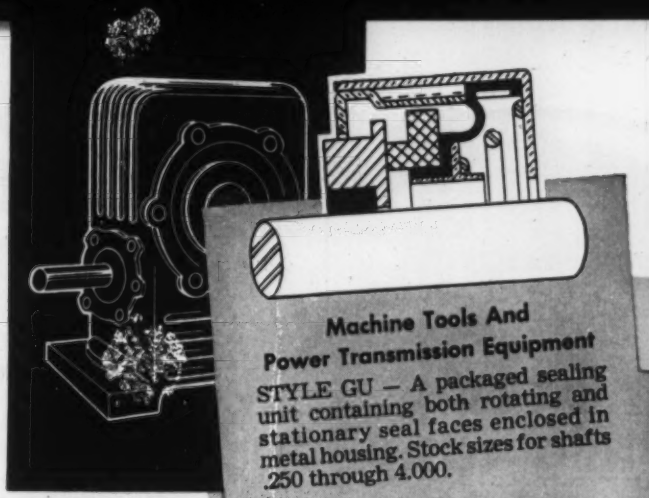
This Fast's Coupling drives a pump delivering heavy naptha to the Solutizing plant.

Engineered Products
Sold with *Service*

KOPPERS

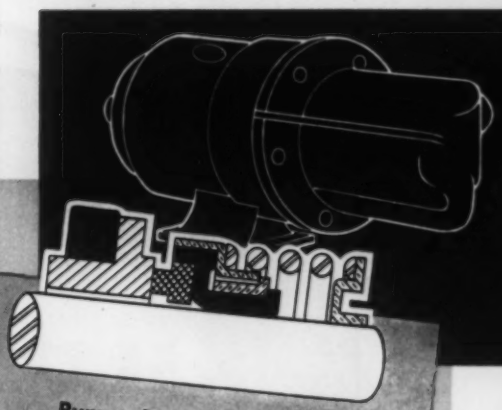
THE ORIGINAL
FAST'S Couplings

Circle 470 on Page 19



Machine Tools And Power Transmission Equipment

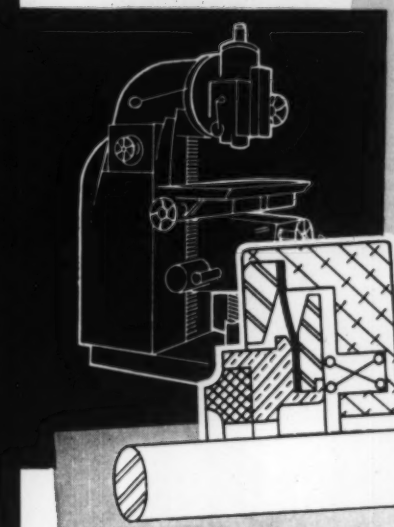
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

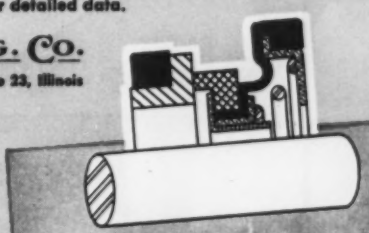
GITS BROS. MFG. CO.

1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century

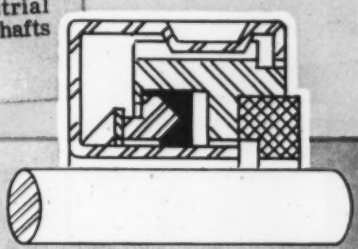
Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.



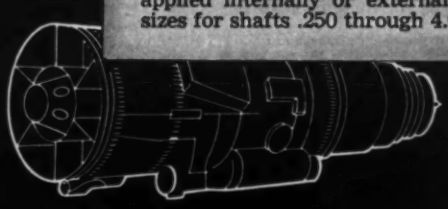
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



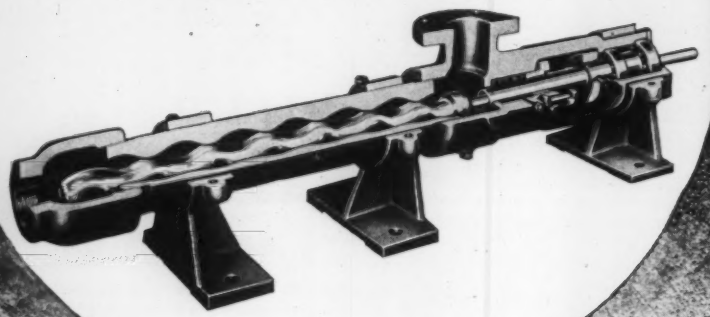
Aircraft Engines And Accessories

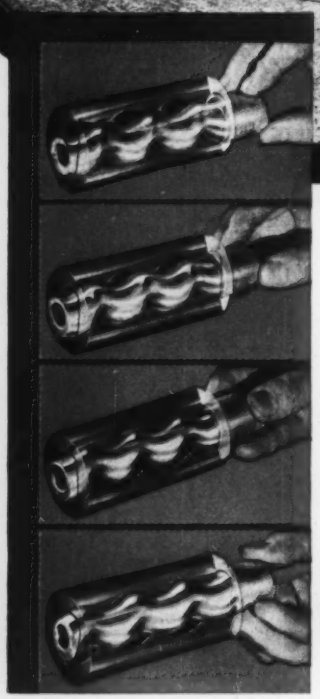
STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 471 on Page 19

IF IT CAN BE PUSHED THROUGH A PIPE... A MOYNO® WILL PUMP IT!





Moyno's exclusive "progressing cavity" principle permits hundreds of formerly "unpumpable" materials to be handled successfully. The screw-like rotor revolves in a double threaded stator forming "progressing cavities" that move the material smoothly without foaming, aerating, crushing or excessive pump wear.

Typical materials pumped include non-pourable pastes, slurries, chemicals, foods, acids, even suspended solids up to one inch in size. Capacities available up to 500 gpm and pressures up to 1000 psi.

No doubt a Moyno Pump can cut costs drastically for you. *Write for Bulletin 30-MD.*

R&M

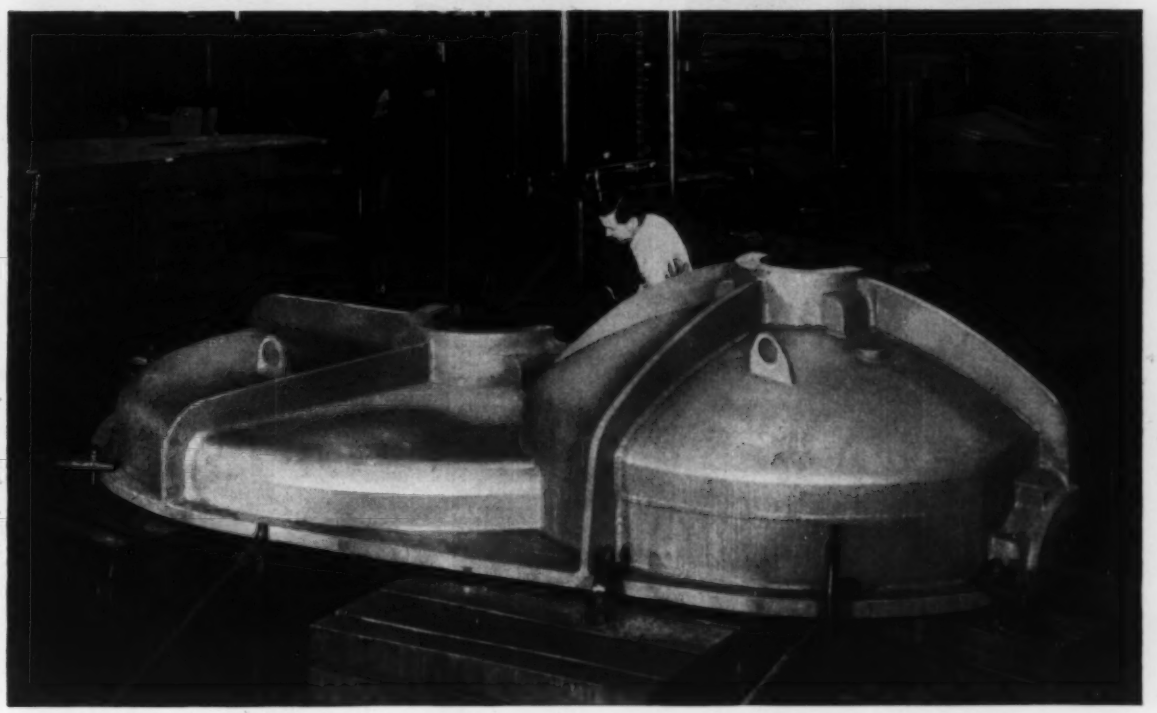
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

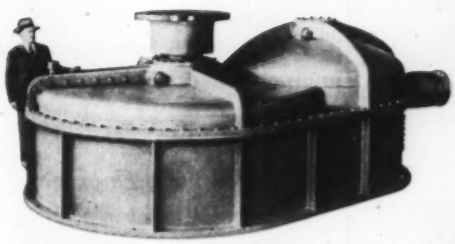
MOTORS · FANS · HOISTS · MOYNO PUMPS · INDUSTRIAL PROPELLAIR FANS

Circle 472 on Page 19

STEEL-WELD FABRICATION . . .



PRECISION WELDMENTS Fabricated and Machined to Specification!



FABRICATED, MACHINED and ASSEMBLED IN THE MAHON PLANT

The weldment illustrated above is one of two similar parts of a gear housing for a large speed reducer. The craftsmanship which is plainly evident in this piece is typical of Mahon precision in the production of thousands of Steel-Weld Fabricated parts and assemblies produced year after year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

When your design calls for weldments of any kind, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon Company you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

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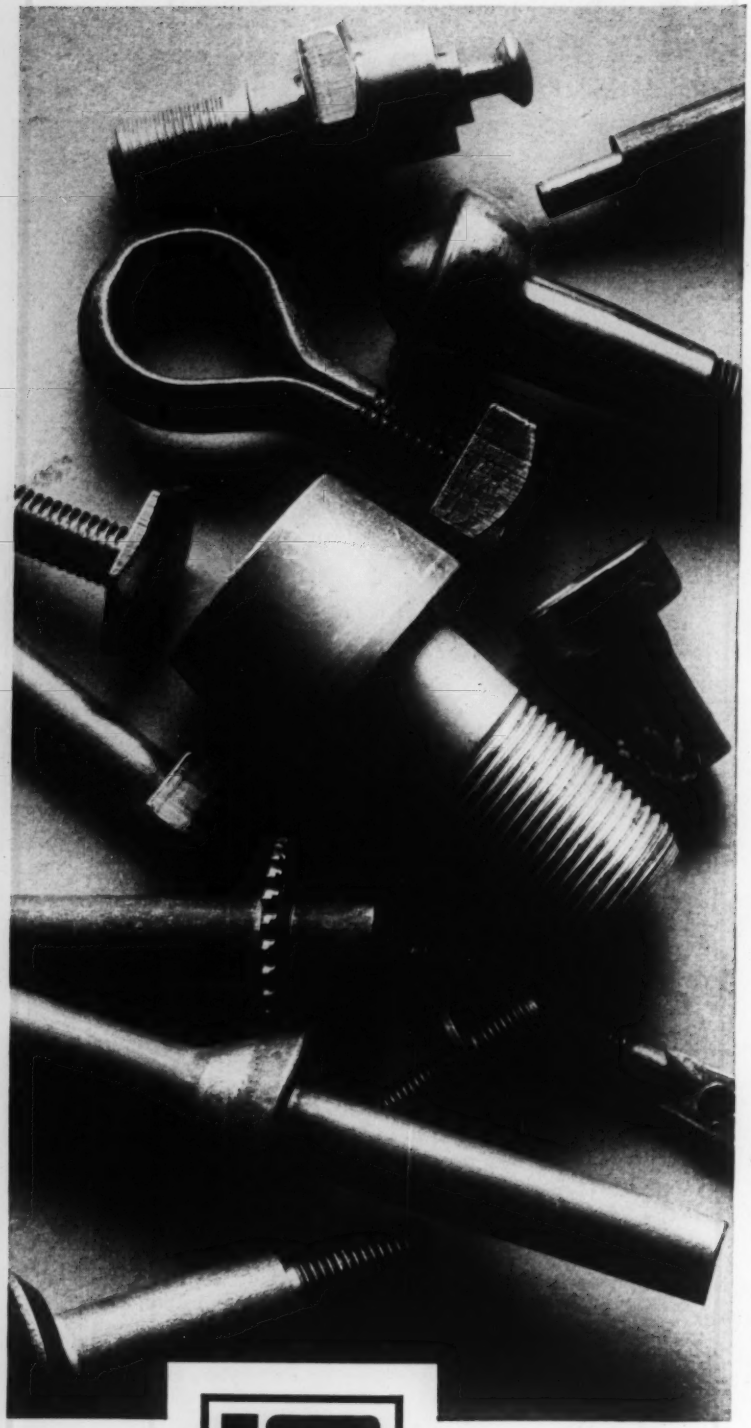

A bolt is a bolt... or is it?

At L & S, "bolts" often take on strange shapes...such as those shown here. Why? Because customers need them that way...to solve a specific fastening problem. Strange thing, though—what may seem very "special" to you may require only a slight modification of something we've already made. We have the know-how *and* the equipment to design it, produce it, economically! Send us your prints or problems.

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MACHINE DESIGN

February 5, 1959

A Feeling for Hardware

PREOCCUPATION with being "professional" has its drawbacks. When engineering was more of an art it was closely allied with the skilled trades. Then an engineer was not considered fully seasoned until he had served an apprenticeship. Formal academic education alone was considered inadequate.

Today engineering is a science—and a profession—and the concept of apprenticeship has almost disappeared. With it has gone a valuable element of engineering training. What has been lost might be described broadly as a feeling for hardware.

The medical profession has its counterpart. In medical school the would-be doctor learns much from dissecting pickled human remains. But that is a far cry from working with warm, live tissues and organs. So the doctor's professional training is not complete until he has served as intern in a hospital. There daily contact with accident and disease give him not only practice in developing working skills but also first-hand feeling for the structure of the human body.

Engineering equivalents of the internship are much less rigorous. They include co-operative education, and the loop training courses given by some of the larger companies to graduates hired straight out of college.

Whenever a company undertakes a training program, there is strong temptation to develop, first, a good "organization man." But such indoctrination should not be at the expense of meaningful practice in the arts of engineering.

As Richard Hoppe puts it in his article overleaf, it is necessary to administer training so that it involves "practice in handling real problems." And if the experience includes time in the shop and occasional dirty hands, so much the better. It will help the engineering intern acquire that invaluable feeling for hardware.

Colin Carmichael

EDITOR

How to organize an effective

By RICHARD E. HOPPE*
Director of Training
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

TO BE effective, an engineering training program must help the new engineer to become productive as quickly as possible and stimulate his desire to excel by planning for his integration into his job, company, and community. Also, it must continue to stimulate the indoctrinated engineer by providing opportunities for professional growth and development.

Programs to accomplish these objectives must be planned so that professional development becomes synonymous with self-development. This article shows how such programs are organized.

Training—What it is and what it should do

Basically, training is helping an individual do a better job or teaching him how to do it in the first place. This is done largely through on-the-job training, personal coaching, and a progression of

*Now Assistant to the President, Van Dale Corp., Long Lake, Minn.

engineering training program

Training—what it is and what it should do
Objectives of an engineering training program
Integrating the new engineer
How to organize engineering supervisory training

guided experiences all closely related to skillful supervision.

Experiences in the actual job situation are the core and substance of engineering training. However, related classroom or group instruction is often necessary in addition to job experiences. New trends, changing technologies, and even deficiencies in college training make these educational activities necessary.

Another concept of training is assisting an individual to develop his ability to cope with his environment more effectively. This kind of training is not always aimed at developing specific skills and is often not related directly to the job. Activities which have been formalized as an indication of belief in such training include courses with outside institutions; in-plant, after-hours courses; professional and technical-society activity; etc. There is often real difficulty in proving the value of such training because of the small amount of direct job carryover.

Training is sometimes thought of as changing the thinking habits or attitudes of individuals. However, attitudes cannot readily be changed in a training program. Evidence indicates that such training is relatively ineffective and results are often negative. Attitudes are changed usually over a long period of time by something other than training and are related to the individual's experiences.

Stimulating employees into action by an occasional "shot in the arm" or an inspirational message should not be considered as training. The effects are short-lived which means that habits have not really been changed. Employees do not learn anything which enables them to do a better job. As with attitude changing, objectives of the inspirational approach are valid. They may be accomplished better, though, through effective day-to-day supervision.

Objectives of Any Training Program: Long-term objectives or goals of any training program should not be considered as being completely obtainable. They represent merely the aim of the program, and efforts to achieve them should be continuous. Al-

Successful engineering training programs

- **Aim to achieve the highest possible level of performance from the trainee.**
- **Develop the trainee as an individual.**
- **Offer methods of improving performance which are centered around the individual and his immediate job assignment.**
- **Provide methods for self-improvement while away from the job.**

though specific activities are aimed at improving the individual and the company, no one program will accomplish both. To achieve results:

1. Relate training objectives to organization objectives. Every activity must be directly pertinent to organizational needs and goals. The program must justify itself as the least costly and most effective way to get desired results.
2. Apply scientific management to training activities. Plan, organize, and control the activity to meet specific business objectives.
3. Administer training so that it involves practice in handling real problems. Check training effectiveness.
4. Make training a function of the line for acceptance and validity, and use staff assistance.

Objectives of an engineering training program

Problems of training engineers are different from those of training other employees. Engineering work is more varied than a typical office or factory job and, often, the total scope of the job is unlimited. Therefore, it is more difficult to identify elements of learning involved in engineering work which may be organized into a training program.

The broad objectives of training still apply to engineer programs. However, the additional objectives of integrating the new engineer and providing opportunities for the indoctrinated engineer for continued growth and development must also be considered.

Engineers cannot be "force fed," nor can they be motivated to want to learn. The desire to learn and improve must be self-generated. Training programs help stimulate this desire and offer opportunities to improve. This concept recognizes that some engineers will take advantage of these opportunities and some will not.

Primary engineering-training goals are achieved with programs which:

1. Improve basic technical knowledge and skill and keep it up to date.
2. Improve understanding of the economic aspects of technical work.
3. Improve ability to manage one's work and maintain good working relations with others.
4. Stimulate and maintain resourcefulness, ingenuity, and creative ability.

Integrating the new engineer

One aspect of engineering training which is of interest to most engineering managers is the integration of new engineers, sometimes referred to as orientation or indoctrination. Proper orientation methods will do much toward retention of engineers.

New engineers should not have to learn by ob-

Aids to professional development

The engineer can be stimulated to develop professionally through a co-operative effort of management and training which

- **Explains benefits derived from memberships and activities in professional societies.**
- **Offers courses to prepare him for professional registration.**
- **Arranges for tuition assistance to earn advanced degrees.**
- **Recommends in-plant transfers to help him gain experience or utilize certain abilities.**
- **Encourages him to publish papers and aids him in manuscript preparation.**
- **Encourages growth in nontechnical areas.**
- **Provides opportunities for outside activities.**

servation or by touring the many plant operations. They should not be subjected to training as a method for screening and selection for certain jobs, nor should they be trained full time. They should, however, be employed for definite job assignments. Training is then organized so that they are accountable first for job results. Participation in training should be over a period of time.

Responsibility for the integration of new engineers is usually fixed with the personnel or training department. Is this proper, or should the engineering department be responsible? Probably all departments should be involved to some extent, but the large part of the responsibility should rest with the engineering department supervisor.

To insure that all phases of the integration program are completed, a check list of experiences to be acquired should be given to the engineer. As each item is covered, it is checked off on the date completed. When the program is completed, the check list is sent to his department head and then to his personnel data file. This, in effect, places part of the control in the hands of the engineer.

How to organize engineering supervisory training

Organized training for engineering supervisors should: Be methodical and systematic, represent what supervisors need, be acceptable to management,

How to "integrate" the new engineer

The Job

Progress on even a simple job gives the new engineer a feeling of accomplishment. Future assignments of increasing complexity add to this feeling and cause more learning to take place. However, initial assignments should be:

1. Of short duration.
2. Within limits of the individual's capabilities.
3. Clearly defined as to work objectives.
4. Checked periodically for progress.

Concept of the total job should include:

1. Nature of professional responsibilities.
2. Importance of continued growth.
3. Nature of future assignments.

Departmental familiarization should reveal:

1. Organization and personnel.
2. Functions of the department.
3. Physical facilities.
4. Methods of operation.
5. Departmental policies.

Frequent, informal reviews of progress tell the supervisor:

1. How well the trainee is doing.
2. How to improve the trainee's progress.
3. What problems, technical and otherwise, need to be discussed with the trainee.

The Company

Since the new engineer must make an adjustment to his company and to his immediate job and department, familiarization should be an adjunct to job responsibilities. It should focus on those operations which are related to his immediate assignment.

Orientation should be over a period of time during the early days of employment and should include:

1. Company history.
2. Major company objectives.
3. Line and staff operations.
4. Company organization and products.
5. Personnel programs and policies.

The Community

The assumption is made that a professional employee who has made a successful adjustment in his new community is capable of higher output than one who has not. For this reason some attention is given to it.

Considerations are:

1. Extent of company concern.
2. Individual community conditions.
3. Nature of individual problems.

The Engineering Supervisor's Role in Training

Although actual training of engineers is accomplished in a formal program, engineering supervisors can contribute to professional growth by

- Selecting qualified people for training.
- Clearly defining objectives of all assignments.
- Assisting new engineers in making the transition from directed development to self-development.
- Creating a favorable climate in which development can take place.
- Assigning increasingly complex work during the indoctrination period to provide a needed challenge.
- Carefully reviewing achievement and progress during each assignment.
- Encouraging the trainee to analyze his progress.
- Assisting the individual in establishing self-development goals.
- Assisting him in planning experiences to achieve them.
- Recognizing individuals of exceptional talent and ability in both technical and administrative capacities.
- Recommending challenging jobs which will make use of individual talents.
- Holding staff meetings often to solve recurrent problems.

be problem oriented, involve both the supervisor and subordinate, and result in improved mutual understanding.

Five steps in organizing such a program are:

1. Define the supervisor's responsibilities by:
   a. Listing the broad areas of responsibility in the total job, not just objectives for the current period.
   b. Making a brief statement of what is to be accomplished in each area.
   c. Covering the job generally but not in detail.
2. Define job knowledge and skill required. With respect to each area of knowledge cover:
   a. Technical requirements.
   b. Administrative abilities.
   c. Intellectual abilities, i.e., perception, verbal, etc.
   d. Personal abilities, i.e., integrity, emotional balance, etc.

So far, this represents what the supervisor needs to learn if he has not already acquired any of the abilities. It is a standard against which individual needs are determined.

3. Determine individual development needs of both the supervisor and subordinate. The individual should be given a chance to include his own personal development goals which might not have shown up in the analysis of his responsibilities.
4. Organize the training program only after:
   a. Determining training needs common to a significant number of supervisors.
   b. Planning to handle only those learning elements that can be taught economically and effectively in groups.
   c. Arranging subjects in a logical learning sequence.
   d. Spelling out the content of each subject.
   e. Determining training methods, i.e., lesson plans, meetings, conferences, etc.
5. Evaluate the results of training during the sessions and from observation of job performance.

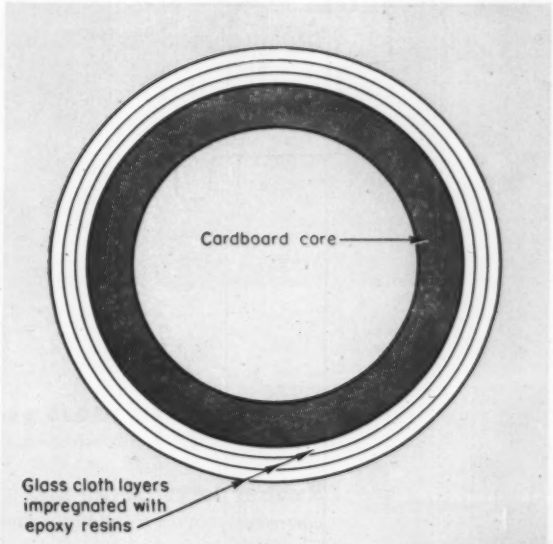
Organization methods covered here represent logical approaches, rather than solutions, to training problems. The ease with which these methods can be adapted to existing programs depends on the seriousness of the problems. Regardless of the work involved, it should be remembered that training, like any investment, should yield a reasonable return.

ACKNOWLEDGMENT

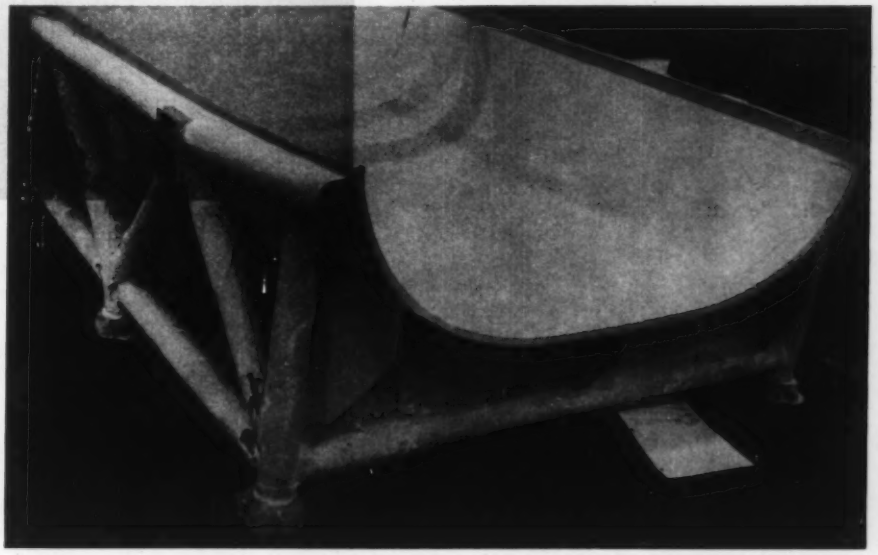
This article is adapted from an address before the American Gear Manufacturer's Association, October, 1958.

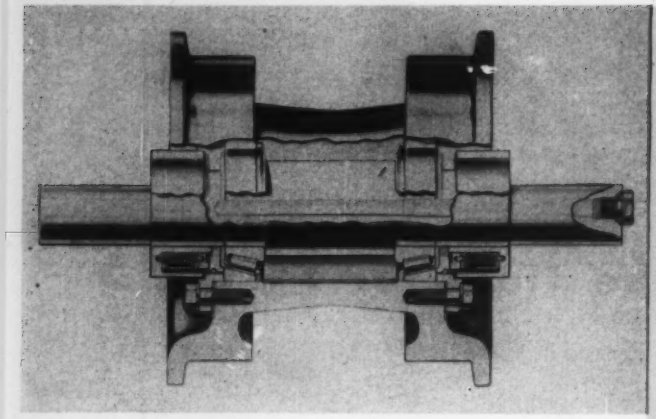
SCANNING THE FIELD FOR IDEAS

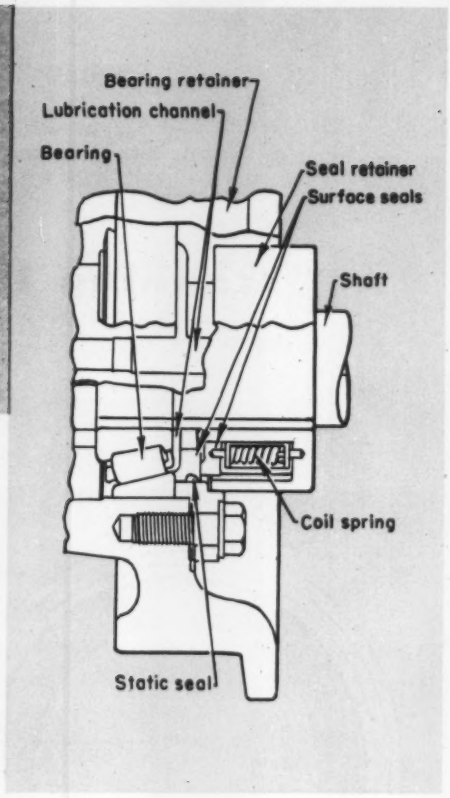
scanning the field for *ideas*



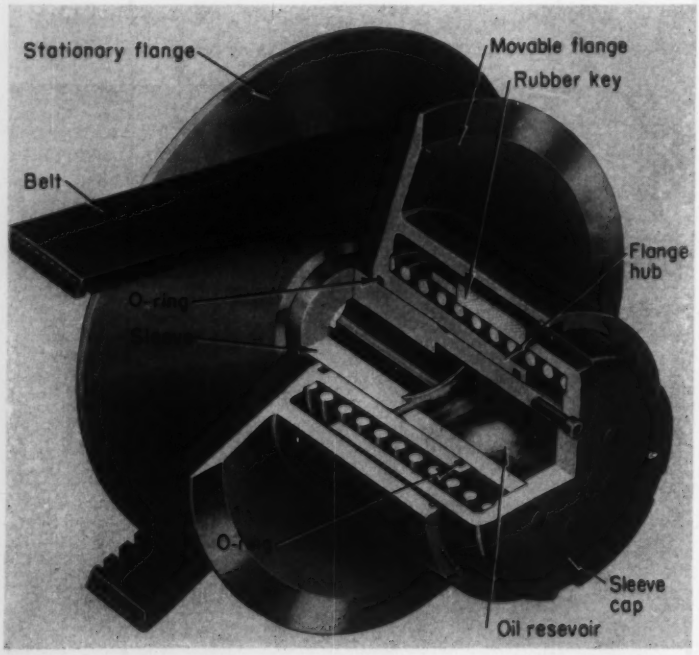
Reinforced-cardboard structural members reduce weight without sacrificing strength. Members are formed by wrapping cardboard cores with layers of glass cloth impregnated with epoxy resins. Size and shape of core and number of glass cloth layers determines ultimate strength of member. Rough texture of glass cloth facilitates handling with plastics. Developed by Rohr Aircraft Corp., this technique is used in fabricating braces for plastic tooling.





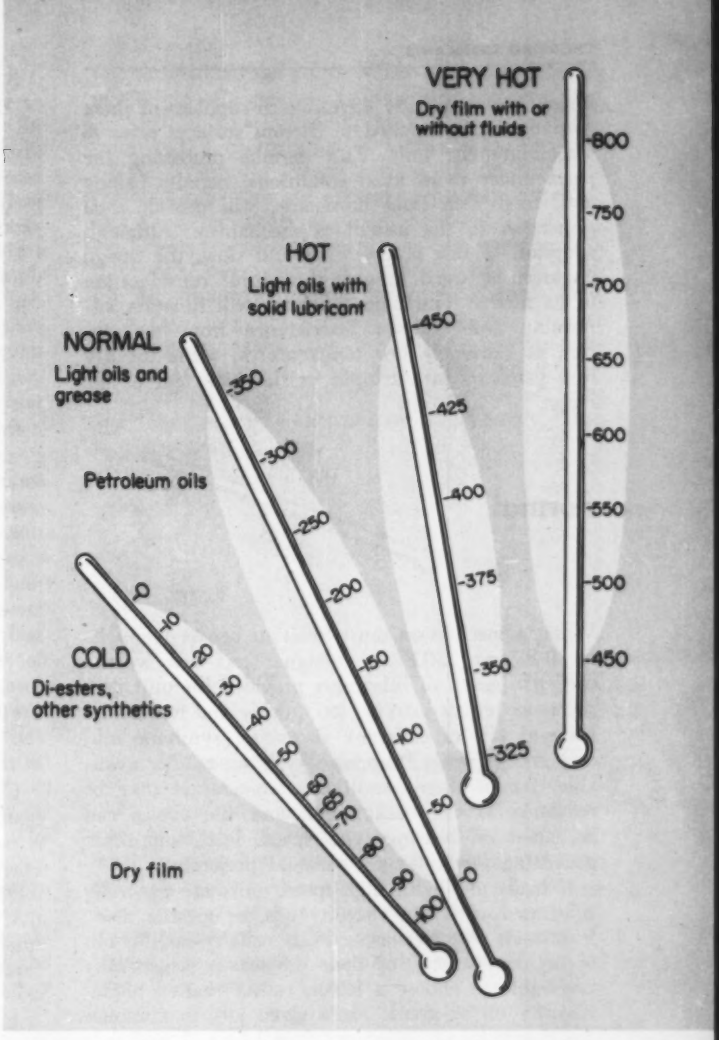


Mating surface seals for heavy-duty bearing applications simplify maintenance and assure leak-tight retention of lubricant. The polished faces of two steel sealing rings are mated together and held in place by a ring of coil springs. One seal ring is stationary, the other rotates to maintain a sealing face and prevents passage of material through seal from either side. Developed by Allis-Chalmers Mfg. Co., this principle is used to eliminate field lubrication of truck wheels and support rollers.



Rubber keys prevent fretting corrosion between sliding surfaces subject to slight relative rotary motions. Conceived by William A. Williams, T. B. Wood's and Sons Co., the key design is employed in a variable-speed sheave for which patents are pending. Lubricating oil is supplied to the space between the sheave sleeve and flange hub through pumping action of resilient keys. The keys produce no radial restraint between sleeve cap and flange hub. Thus, the flange shifts freely in the direction of belt pull at every angular position of the pulley, opening and closing the space between hub and sleeve, and permitting continual lubrication to eliminate the possibility of fretting corrosion. O-rings retain oil at either end of hub.

Choosing lubricants for heat and cold



By ALDEN CRANKSHAW
Lubrication Consultant
Port Huron, Mich.

TEMPERATURE variations can immobilize the best-designed mechanism if the lubricant fails. How can the design engineer forestall such fiascos? This quick review and guide to lubricant selection for severe conditions offers specific recommendations.

cold

Usual limit of the low-temperature range is the requirement of −65 F customary in the aircraft industry. Principal lubricants used in this region are synthetics such as di-esters, which have a relatively narrow range, but which function well at these extremely low points. Principal disadvantage is their instability at the higher temperatures found at ground level, particularly in the tropics. When a unit must operate over a range from −65 F to 130 F, for example, the physical characteristics of the lubricant must be carefully considered.

A number of other lubricants, including some mineral oils and greases, perform well in this range, *if properly applied.* The lubricant must be applied in such a way as to leave an extremely thin film on friction surfaces. The same care should be taken as in the use of dry films. Too liberal application of these products will cause the lubricant to solidify, and the mechanism will "freeze," literally, at extremely low temperature. When di-esters or other low-temperature lubricants cannot be used because of possible deterioration at the upper end of the

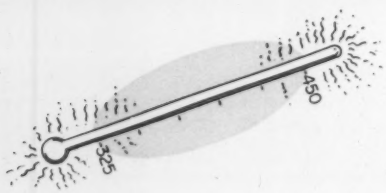
range, it is frequently advisable to supplement them with dry films, applied to friction surfaces prior to assembling the unit. This permits processing the parts under more ideal conditions, permits baking and, used with fluid lubricants, will provide dual protection to the assembled mechanism. Although adoption of this procedure is still slow, the design engineer is urged to give thoughtful consideration to its merits. The fluid lubricant will function admirably and without interference from the dry film at extremely low temperatures, while the dry film performs satisfactorily at the high end of the range.

normal

When a mechanism must function between, roughly, 0 F and 350 F the designer has few worries over his choice of lubricants provided his unit does not reach either extreme too quickly and frequently. Mineral oils of different viscosities, synthetic oils, and greases made from each type are readily available. Under these conditions, temperature may be relegated to the background, and the choice can be based on bearing type, speed, load, and other governing factors—even personal preference.

If loads are light, high-speed units are generally lubricated with low-viscosity oils, or greases made from such oils. Increasing loads usually call for oils of higher viscosity, or their greases. It is generally preferable to choose a lower, rather than a higher viscosity oil or grease for a given job, to minimize the possibility of "lubricant drag." Oils of relatively low viscosity show superior performance when solid additives are used with them. The more common additives will be discussed later.

hot



As temperatures rise over 350 F, the designer's problems become more serious. Many petroleum oils start to deteriorate, particularly in the presence of air. Under such conditions oxidation of the oil increases the viscosity and the tendency to cause corrosion. Oils of relatively low viscosity are prone to evaporation, which may result in partial or complete loss of lubricant. At these temperatures oil viscosity usually diminishes if the unit operates in complete absence of air. In practice, air is always present in some degree, so an increase in viscosity is generally observed with increasing temperature.

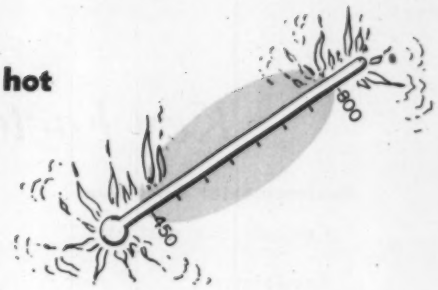
Solid additives are frequently used with petroleum or synthetic oils. These are usually colloidal graphite or colloidal molybdenum disulfide, properly dispersed to assure suspension of the solid over a considerable period of time. Such products are generally stable against settlement for one or more years. In use the solids are absorbed on friction surfaces. Frequently the use of such solids will reduce the coefficient of friction by 20 to 50 per cent. An added advantage is the ability of solid lubricants to serve as lubricants after their oil carriers have been dissipated through excessive heat or other causes. Considerable added life may thus be obtained from the unit.

When operating temperatures greatly exceed 350 F, the lubricant problem becomes more serious. Deterioration of petroleum oils is more rapid, with consequent increases in viscosity and corrosive action. With low-viscosity oils, evaporation is soon complete. Here again the designer is urged to employ solid additives or pretreatment of friction surfaces with dry films. These procedures are particularly effective when loads are light. With heavy loads, the designer should consider greases made from high-viscosity oil bases. Another solution is to use ball bearings, whose action tends to check separation of oil and soap by "reworking" the grease in the bearing.

Greases which contain the solid lubricants mentioned also are available. Settling out of the solids is not a problem in greases, hence they often contain the solids in larger particle sizes than can be tolerated in oils, where extreme fineness is essential. For this reason the use of greases containing solid additives is usually discouraged by manufacturers of antifriction bearings, since the too-large solid particles can cause excessive wear.

In this temperature range vegetable or animal oils are often used. Peanut oil is frequently a successful choice, and lard oil is often a favorite. These oils are more often chosen for use in bearings which permit replenishment of the lubricant, since deterioration with age or excessive temperature does occur. When an oil (or grease) is replaced with a fresh supply, it is desirable to apply the fresh lubricant so as to force the old supply out of the bearings.

When the temperature range is such that no combination can be expected to perform over long periods of time, a low-viscosity oil plus a solid additive will frequently perform excellently. For example, an oil of 60 to 100 seconds viscosity containing a small quantity of colloidal graphite makes a very good lubricant for oven chain conveyors operating at temperatures well above the 350 F range. The light oil penetrates the bearings, carrying the solid to all parts, and is then evaporated at the oven temperature, leaving the graphite behind to serve as a lubricant for the friction surfaces. This procedure is used by many manufacturers of high-temperature lubricants. In practice, relubrication of a fairly well loaded conveyor operating through an oven at 350 to 450 F or higher is required only at 10 to 14-day intervals.



When temperatures exceed 450 F, the designer's problems are multiplied. Difficulties may be introduced by the solid lubricant. At 600 F, molybdenum disulfide begins to decompose under heat, the speed of decomposition increasing rapidly with higher temperatures. Under these conditions the safest choice is graphite. Molybdenum disulfide's decomposition product is molybdenum dioxide, an abrasive solid. However, the result of too high temperatures on graphite is carbon monoxide or carbon dioxide, both of which are gases.

There is a fairly widespread belief that graphite is not a lubricant except in the presence of moisture. This concept has arisen through the published works of Savage and others, whose demonstrations of failure of graphite motor brushes in complete absence of air have been read too hastily. The fact is that graphite *alone* exhibits such tendencies, but in the presence of a number of solids and gases, graphite functions perfectly in the absence of moisture. Some of these materials, fortunately, are present in cases of this sort. Colloidal graphite is the design engineer's safest choice when his unit must operate at temperatures in excess of 600 F.

When temperatures approach 800 F, liquid or semiliquid lubricants may no longer be considered. The designer must then depend on dry-film lubricants. While dry films are less satisfactory than oils under normal conditions, at 800 F normalcy no longer exists and the use of dry films is the only alternative.

Dry-film lubricants are generally applied to the friction surfaces of component parts prior to assembly of the completed unit. They usually consist of graphite or molybdenum disulfide, or both, together with a resin and a solvent. The resin constituent is chosen for its particular suitability to the conditions under which the finished product is to operate. Varying percentages of solvent may be used, depending on whether the film is to be applied by spraying, brushing, or dip coating.

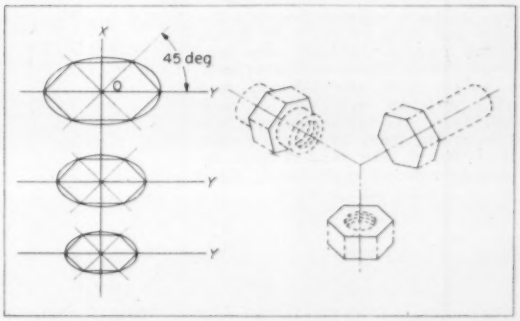
Because more accurate control of film thickness can be obtained through spray coating, this is the preferred method. Dipping is possible when the material is properly diluted with a compatible solvent. Parts should be so handled as to prevent the formation of "tears" when draining and drying. Film thickness is kept to a minimum, and seldom is greater than 0.001 inch; preferably it should be about one-half that figure. With some resins, curing may be accomplished only by baking parts at an elevated temperature. With others, air drying or the use of a catalytic agent effects the cure.

When a wide variation in temperatures is encountered, a combination of lubricants is often desirable. When the range is from 300 to 850 F, for example, dry films are applied as already described, and fluid lubricants are also employed. This provides satisfactory performance at the lower end of the range. When the upper limit destroys the fluid, the dry film will function for a considerable time, even providing fairly effective lubrication in case temperatures again drop below the extremes previously encountered. Thus actual damage to friction surfaces is avoided through the use of these dry films, unless a mechanism is deliberately run to destruction.

Tips and Techniques

Isometric Hexagon Template

For drawing hexagon features of such parts as nuts, bolts, and pipe unions in isometric, a template made from an isometric ellipse template can be useful. Draw an ellipse exactly centered on an x-y axes. From point 0, at the intersection of x and y, lay out lines of 45 deg. An isometric hexagon is formed by connecting the points of intersection of these lines and the ellipse.



The isometric hexagon template is obtained by laying out several of these hexs on the x-axis, placing a piece of clear plastic over the layout, and cutting through the plastic. An inked line of the x-axis is then made on the plastic to serve as a guide when the line is made to coincide with one of the three isometric axis.

To produce a hex head, draw one complete hexagon, move the template along the axis a distance corresponding to the thickness of the bolt head, draw a half hex, and connect the two hexes with four parallel lines.—Robert Deatherage, *Roger & Roger Inc., Edgewood, Md.*

Key Factors

Environmental Conditions

- Coolants, oils, dust, etc.
- Temperatures
- Corrosive vapors
- Shock and vibration

Actuation System

- Impact of actuation
- Actuation-force direction
- Overtravel

Contact System

- Number of circuits
- Electrical loads

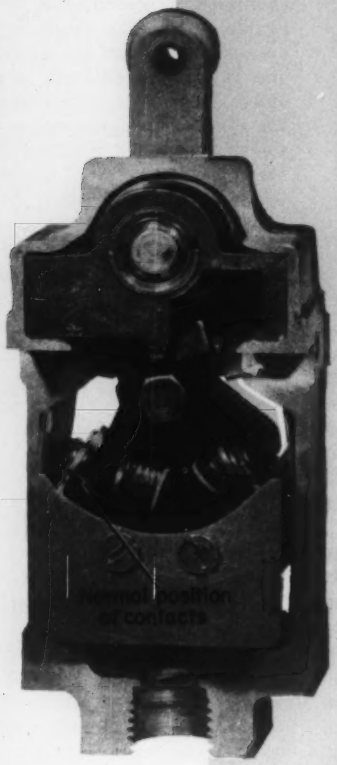
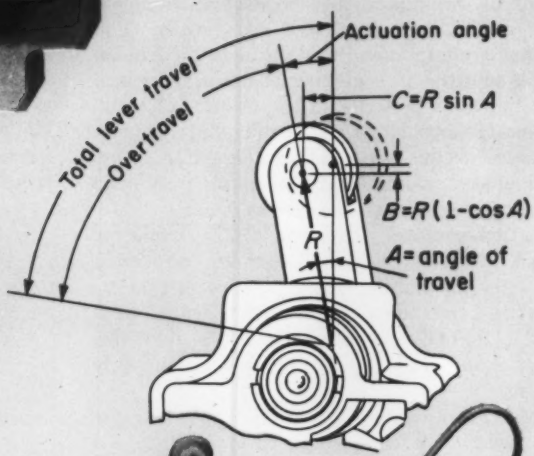


Fig. 1—Heavy-duty limit switch actuated through only a 10-deg movement of operating lever. Although this particular design permits 70 deg of overtravel, life of spring mechanisms can be greatly extended by minimizing amount of actual overtravel used



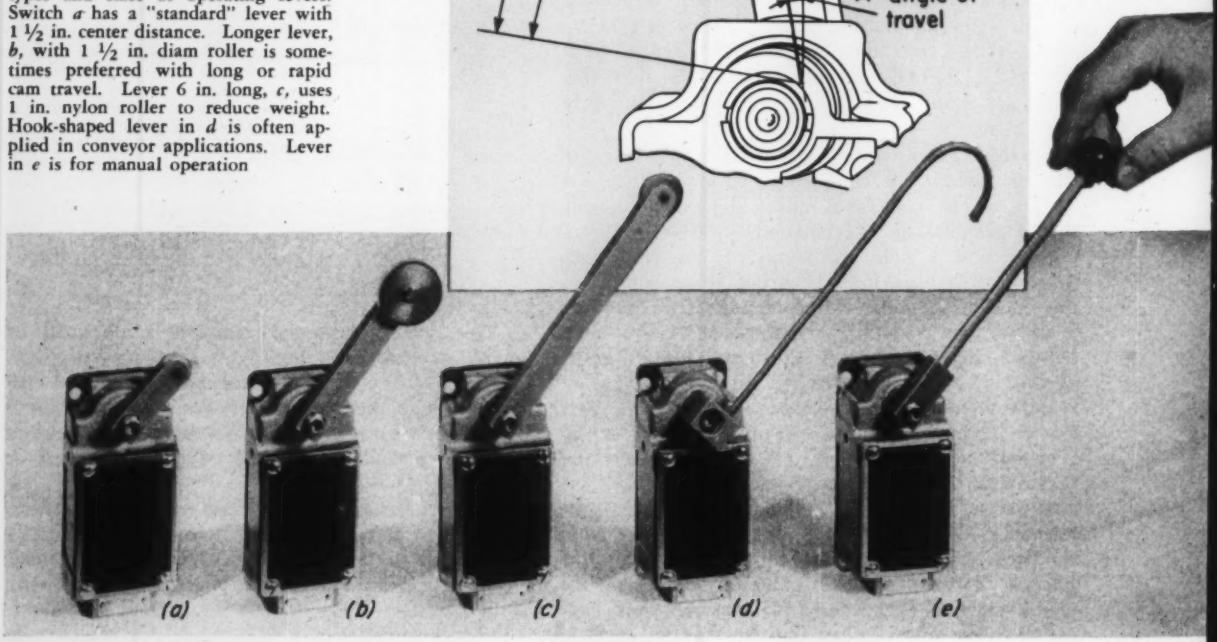


Fig. 2—Limit switches with various types and sizes of operating levers. Switch *a* has a "standard" lever with 1 ½ in. center distance. Longer lever, *b*, with 1 ½ in. diam roller is sometimes preferred with long or rapid cam travel. Lever 6 in. long, *c*, uses 1 in. nylon roller to reduce weight. Hook-shaped lever in *d* is often applied in conveyor applications. Lever in *e* is for manual operation

In Applying . . .

HEAVY-DUTY LIMIT SWITCHES

By ROBERT B. DENISON
President
R. B. Denison Mfg. Co.
Cleveland, Ohio

WELL-DESIGNED heavy-duty limit switches can be expected to operate 10 to 20 million times—both mechanically and electrically. But such potential life can be realized only if switches are properly mounted, actuated, and protected. Otherwise, they may receive unsuspected abuse and, hence, fail prematurely.

Environmental conditions and actuation design, besides the electrical loads, greatly influence switch operating life. Selection and design factors essential to trouble-free performance and long life are detailed in this article.

▶ Environmental Conditions

Although many pieces of electrical equipment can be kept remote from the center of action of a machine, a limit switch generally is located, perforce, close to parts being machined, transported, or otherwise controlled. Therefore, every effort should be made to protect it from unfavorable environmental conditions, such as high humidity, flying coolants and cutting oils, dust or other contaminants, extremes in temperature, corrosive fumes, severe shock and vibration.

Flying Liquids and Debris: Most heavy-duty limit switches are designed with housing gaskets and shaft seals. These gaskets and seals are adequate for an occassional splash of water, lubricating coolant, or cutting oils as well as a reasonable amount of dust. However, such switches are not designed for conditions that approach submersion. And the switch is not protected from condensation of moisture caused by extreme temperature changes, particularly that

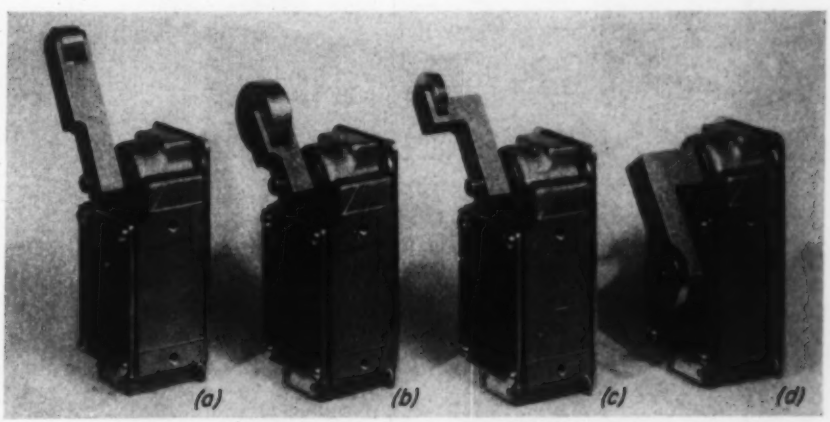


Fig. 3—Offset switch-operating levers for solving special mounting or actuation problems. Levers on switches *a* and *b* are only slightly offset. Those in *c* and *d* are available with offsets up to 1 in.

Fig. 4—Switch with watertight acrylic-plastic cover and metal frame. Compression-type fitting provides good method of sealing four-conductor cable where it enters the switch

Fig. 5—Precision type switch in *a* equipped with "one-way" spring-loaded roller which permits actuation of switch when cam moves to the right but not on return. "Knee-action" lever in *b* accomplishes much the same thing as partial roller in *a*. Two designs of adjustable-length levers are shown in *c* and *d*

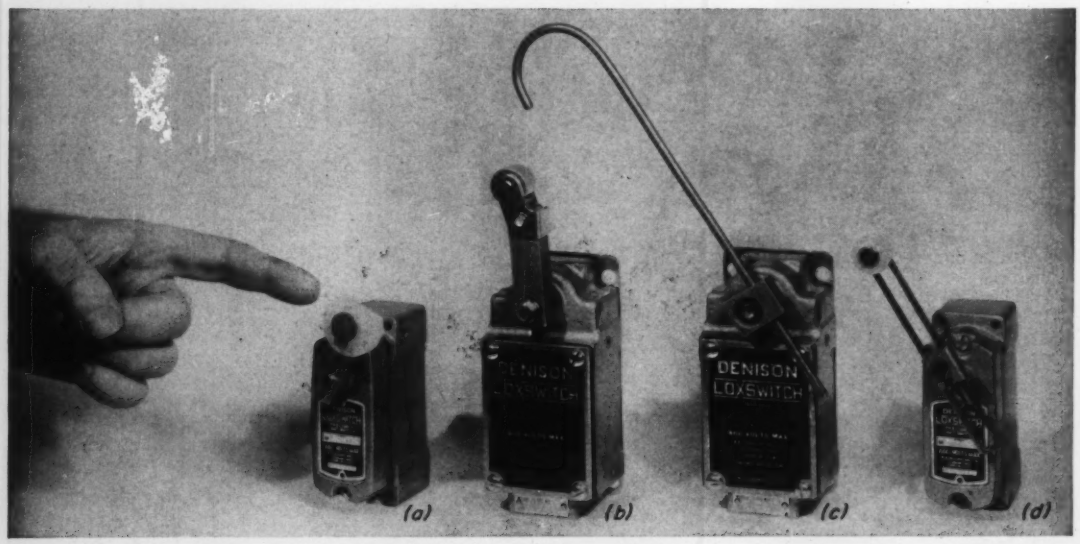
accumulated in the connecting conduit.

Mounting height and location can make a big difference in switch protection. Mounting a switch a few inches higher or lower, or to one side, will frequently remove it completely from a continuous flow of coolant or cutting oils. Mounting a switch in a location different than originally planned may sometimes require relocation of the actuating mechanism. Frequently, the desired change can be produced by mounting the switch elsewhere and adding a longer lever on the limit switch, Fig. 2, or in some cases Z or offset levers can be used, Fig. 3. Also, an inexpensive metal shield can be added to deflect the liquid flow or spray.

Since moisture often enters the switch through the conduit, attention should be given to alternate methods of wiring the switch. Often the conduit can be depressed just prior to entering the switch and provided with a drain hole at this point. In other cases the conduit can be brought up from below the limit switch. A preferred method is to use a sealed conduit such as a two-conductor or four-conductor synthetic-rubber cable entering the switch through a compression seal, Fig. 4.

Temperature: In general, electromechanical limit switches are unaffected by elevated temperatures within the range specified for conductor insulation, namely in the neighborhood of 175 F. In fact, most of them will operate satisfactorily at temperatures to 250 F. However, insulation in limit switches as in all other electrical devices deteriorates rapidly at these elevated temperatures. Therefore, switches exposed to high temperatures encountered around industrial furnaces or other heating equipment should be shielded from any concentrated heat.

Corrosive Fumes: Standard limit switches are not protected from the corrosive attack of various acid fumes, such as those encountered around bright-dip processes. Most heavy-duty limit-switch housings are



commonly constructed of die-cast zinc which is readily attacked by fumes in such processes. Although some switches are available in aluminum housings, which do offer greater resistance to these fumes, the switches themselves cannot be considered hermetically tight. Also, since the internal mechanisms are made of steel and other materials readily attacked, they cannot be considered completely satisfactory for corrosive-fume environments.

Precautions of sealing the housing, particularly at the conduit end, will greatly lengthen the life of the aluminum-housed switch under these conditions. However, it may be advisable to use the light-duty hermetically sealed switches commonly applied in aircraft and insert at suitable distance from the fumes such additional relays as may be necessary for these light-duty switches.

Shock and Vibration: In many applications, particularly on heavy punch presses and die presses, electrical circuits may be interrupted by shock and vibration from the impact of the presses. Under these circumstances careful consideration must be given to the mounting position of a limit switch. Low contact mass and high contact pressure are also very important under these adverse operating conditions. Wherever possible the switch should be installed so that the direction of shock forces is in an entirely different plane from the direction in which the switch contacts open or close. Where this is not possible, the use of a double-pole switch designed with contacts operating at sharply different angles and wired in parallel may be a solution, Fig. 10.

▶ Actuating System

Another key factor in long limit-switch life is a properly designed actuating system.

Angle of Pressure: Operating life of limit switches is greatly affected by the angle at which the actuating force is applied, Fig. 6. Since a lever-operated limit switch is essentially a rotating device, the pressure angle should be as nearly as possible in the direction of rotation, with a variation not to exceed 30 deg. As illustrated in Fig. 6 to 9, cam design and positioning of the switch lever are inseparably related.

Impact: Excessive impact from improperly designed actuating systems is without question the leading cause of premature failure of the electromechanical limit switch. At slow speed, impact is rarely a design problem.

High speed is a comparatively new factor of great importance in limit-switch actuation systems used in today's machines. As speed increases, impact applied to the switch increases. Therefore, protection of

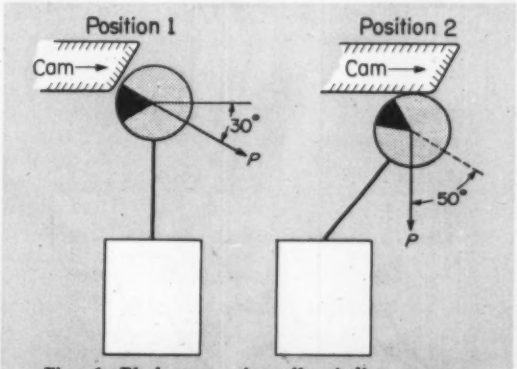


Fig. 6—Black sector in roller indicates recommended design limits of angle of pressure, P. Pressure applied by actuating mechanism to switch operating lever should approximate direction of lever rotation and should not exceed ± 30 deg. Angle of pressure changes drastically with the rotation of lever. Cam must be designed for proper pressure angles at all positions of lever travel

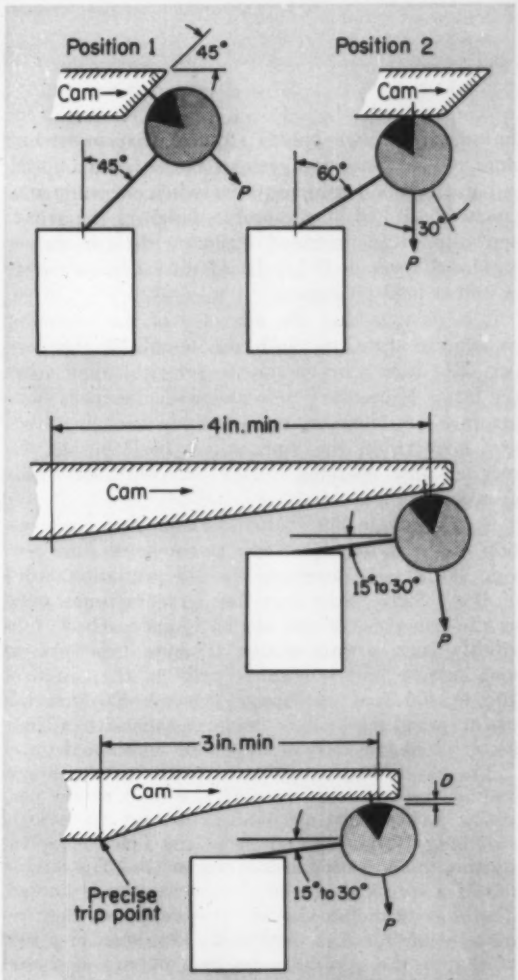


Fig. 7—Switch levers should be positioned as nearly parallel with leading edges of cams as possible. Cam at top is satisfactory for speeds to 50 fpm, middle for speeds to 200 fpm (nonuniform acceleration of switch lever), and at bottom to 400 fpm (uniform or other controlled acceleration)

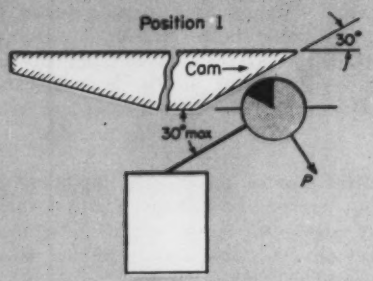


Fig. 8 Actuation cam designed with a trailing edge so it can override the switch lever and then return. Cam actuates switch on return, too. This design is satisfactory only for occasional overriding and returning service. Lever angle is very important in applications of this type

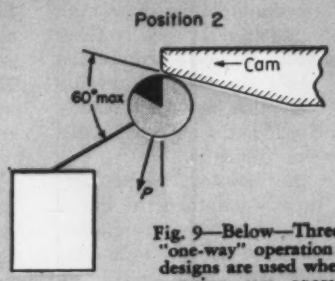
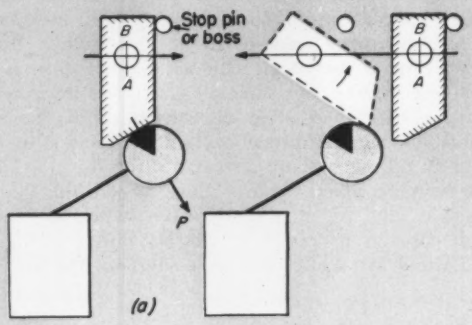
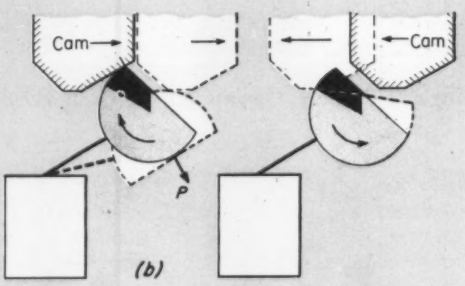
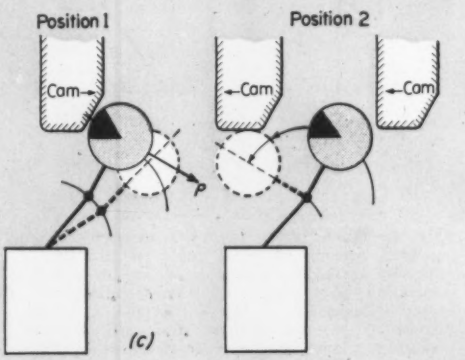


Fig. 9—Below—Three methods of providing "one-way" operation of limit switch. These designs are used where overriding and reciprocating cam operation is repetitive and switch actuation on reverse motion of the cam cannot be tolerated. Inexpensive trip dog in *a* requires no springs for its operation. Spring-loaded, partial-roller design in *b* can be used for reasonably high-speed operations. Folding switch-lever design in *c* is suitable only for low speeds







the switch at high speeds requires that somewhat more refined actuation systems be designed. Speed and acceleration imparted to the switch operating arm can be controlled by the profile design of the actuation cam. Recommended actuation designs shown in Fig. 6 through 9 are based on laboratory tests as well as field experience.

It is obvious that the accuracy of the camming mechanism decreases with the length of the cam rise. But it is believed that in practical application the factor of accuracy decreases with the speed, taking into consideration the switching time involved, not only within the limit switch itself but in the magnetically operated relays or controllers connected to it.

Bottom cam in Fig. 7 produces controlled acceleration of the switch lever and at the same time provide far greater accuracy for the actuating point of the switch. Note that the curve becomes steep as the trip point of the switch is approached. Obviously such a cam design is more expensive to manufacture and is required only in the range of 200 to 400 fpm. At speeds beyond 400 fpm the use of special actuators or the more-expensive proximity or electronic devices should be considered.

The electromechanical limit switch contains a system of springs; some provide the snap action necessary to convert mechanical motion to electric switching. Other springs serve the function of returning the operating arm of the switch. The fatigue life of a spring is greater if its deflection is limited. Therefore, switches should be installed so they require a minimum of overtravel. However, as a rule of thumb, the minimum designed overtravel should be $\frac{1}{3}$ to $\frac{1}{2}$ of that required to operate the switch and the maximum designed overtravel should not exceed 10 deg.

Limit switches are now readily available which provide in excess of 50 deg overtravel for the lever-type switch. Despite these provisions it must be

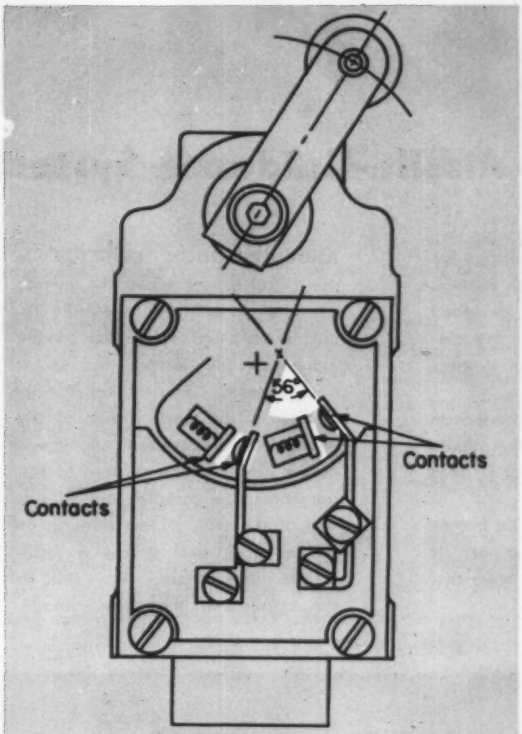


Fig. 10—Double-pole switch with contacts mounted at sharply different angles. This design helps protect against circuit interruption under high-shock conditions

remembered that continuous excessive overtravel will greatly reduce the life of the spring mechanisms and, therefore, the life of the mechanical functions of the switch. Such overtravel, beyond the limit indicated above, should therefore be utilized only for emergency or infrequent requirements.

Emergency and "Designed" Travel: Actuation cams should be designed for a minimum amount of overtravel of the switch mechanism, consistent with available adjustments of the switch lever, possible variations in distance between the switch and the actuating cam, and wear of the mechanisms involved. In general, a maximum of 10 deg overtravel is entirely adequate. However, need for additional travel may arise from a number of causes, such as drifting of a machine or conveyor mechanism, malfunction of another element, or manual operation during setup. A switch must be protected against operation beyond its full overtravel range.

Usual operations may require travel far beyond the switch-actuation point followed by reverse travel over the same switch. Such reverse travel can easily exceed the overtravel capacity of the switch, particularly if the lever is mounted as in Fig. 7, top; if this type of cam were to operate the switch in the reverse direction, the reverse overtravel required would be 105 deg, which is beyond the capacity of any known limit switches. Wherever there is a possibility that the cam may override the switch lever and then return, the switch must be protected by a properly designed trailing edge of the cam, Fig. 8, or by suitable "one-way" devices, Fig. 9.

▶ Contact System

Since much has been written about the selection of limit switches from the standpoint of contact arrangements, only a few of the important factors will be pointed out here.

Number of Circuits Per Switch: Incidence of failures can be reduced, and much space and wiring saved, by using multiple-circuit limit switches. Double-pole or neutral-position switches, for example, can frequently replace two single-pole switches or eliminate the extra relays necessary to provide double circuits operated from a single-pole switch. Where completely isolated circuits are required, such as one circuit for a motor control and one circuit for the timing device, double-pole limit switches are available to provide simultaneous switching of two completely isolated circuits. Such switches can also be used in complex automatic machines to permit operation of interlocked circuits in one section even when another section of the same equipment has been cut out because of an open circuit.

Emergency and "Designed" Electrical Loads: Size and electrical rating of a limit switch must be carefully selected on the basis of electrical loads encountered with the failure or jamming of some other electrical device in the circuit, as well as the normal electrical loads expected. For example, a solenoid jammed in the open position will draw 8 to 10 times as much current as required in a closed position. If this solenoid is operating a mechanism, such as a magnetic brake, the adjustment of the brake may hold the solenoid partially open and greatly increase the electrical load. In general, the inrush current of relays and solenoids, although 8 to 10 times the holding current, is only momentary. However, if these other devices fail to operate, the current through the limit switch will remain at a high level. If this hazard exists, a switch must be selected to carry such current continuously.

They Say . . .

"Since the individual is a vital link to the dynamic society within our reach, he should be cultivated, encouraged, and permitted to work in an intellectual climate. He should be given the incentive to excel. If we as a nation are to attain the stature of which we are capable, we may have to improve our methods of rewarding the creative impuse."
—JOHN T. RETTALIATA, *president, Illinois Institute of Technology.*

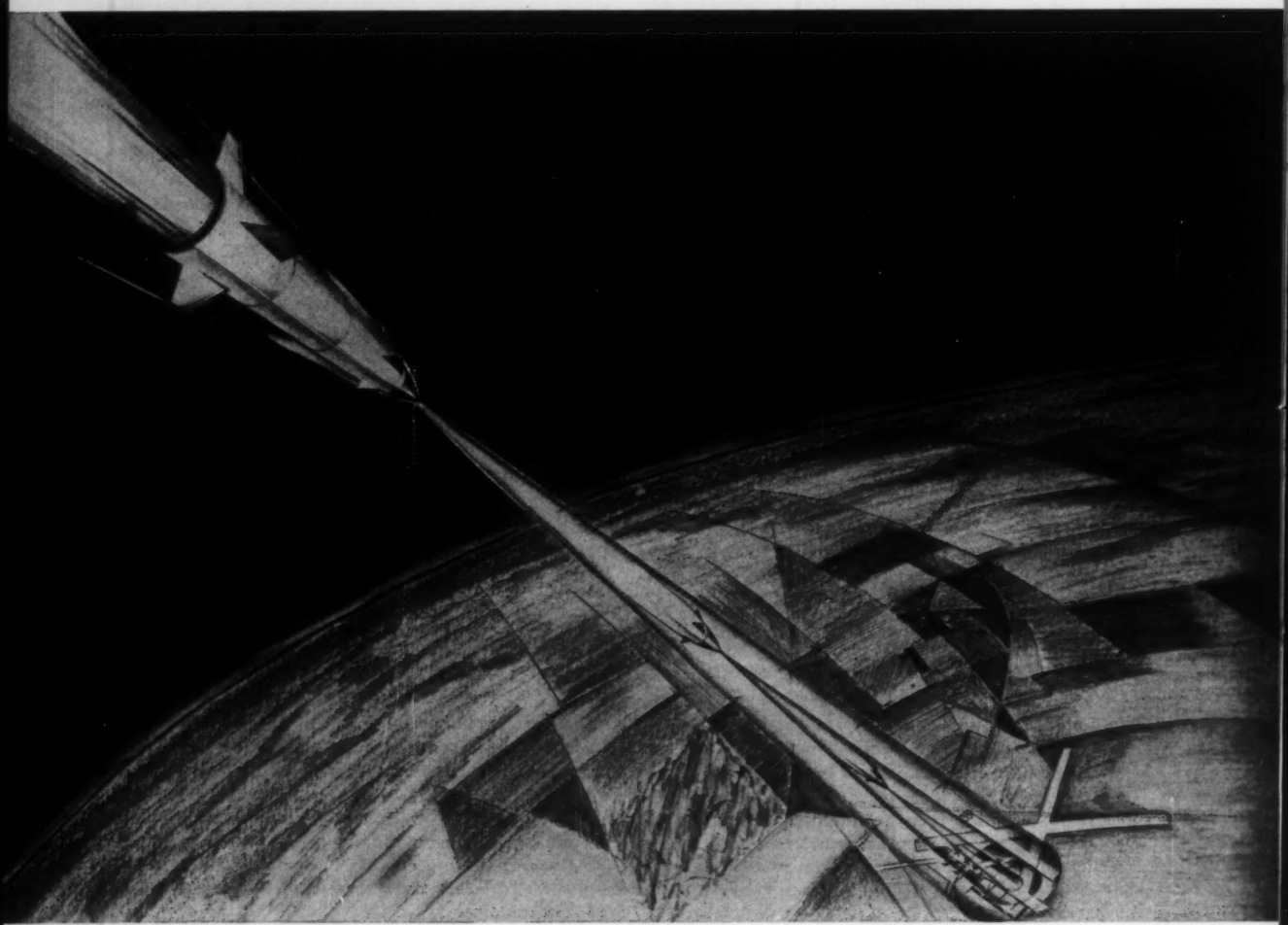
Optical Missile-Guidance System

OPTICAL SENSING SYSTEM, developed by Chicago Aerial Industries for air-to-surface missile guidance, uses actual target image for control. The system, known as SOLO for Selective Optical Lock-On, is designed for either direct-line-of-sight or video-data-link aiming. After the missile is released from the plane, no prolonged tracking or signal averaging is necessary.

The system is so sensitive that the missile will not vary more than 2.5 milliradians from the original line of aim. Therefore, if the missile is fired at a 1-mile range, it will deviate no more than 13.2 ft from the original point of aim on the target.

The unit operates at any altitude to 40,000 ft or more and homes in on targets lighted to brightnesses of 5 footlamberts or greater. It will lock on any heterogeneous area having a light-contrast ratio discernible to the unaided human eye.

ANGULAR-MOTION DETECTOR in the SOLO senses when the missile starts to get off target. A null signal is obtained when the missile moves directly toward the target area selected. Any motion at right angles to the optical axis of the missile will be detected. An image of the light-contrast pattern of target enters the complex optical system of the unit, passes through an optical grid, and strikes a lead-sulfide light sensor. Any shift in the pattern of the target image,



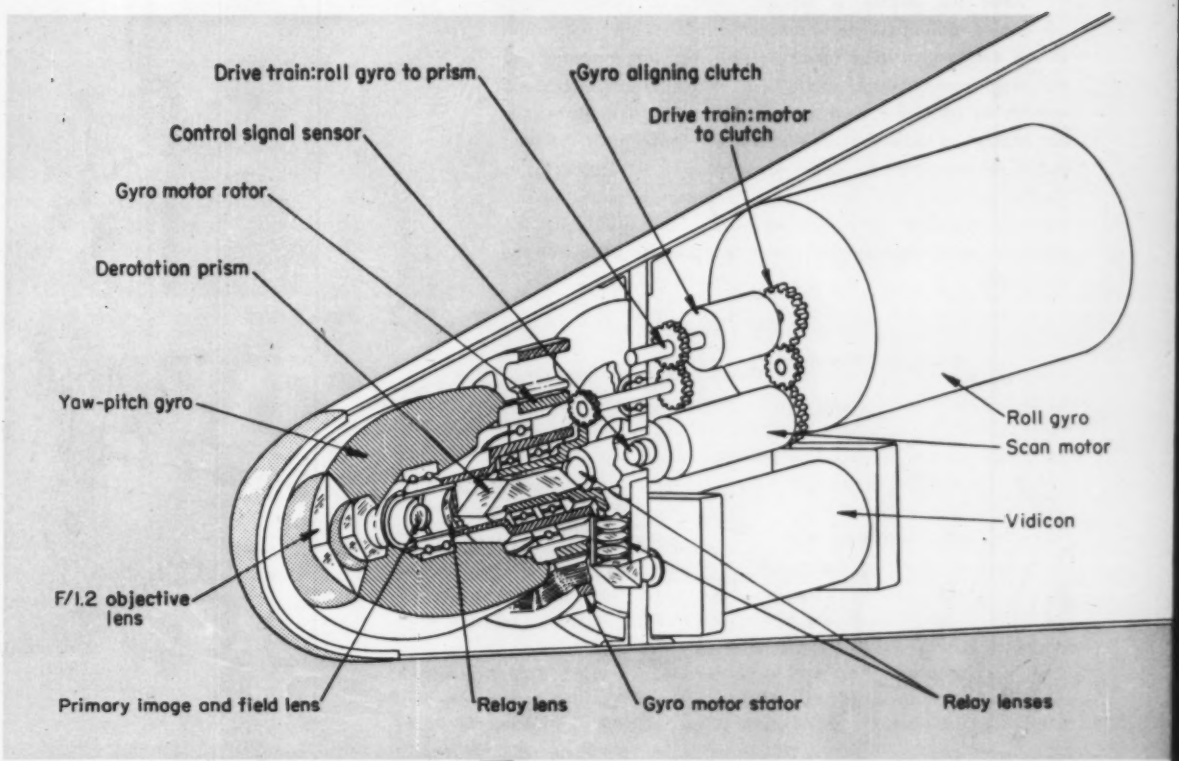
Designed for 2.5-milliradian Accuracy

which occurs if the missile starts to go off course, produces a corresponding signal change in the sensor. Output from the sensor is fed to a transistorized control circuit in the missile autopilot which corrects direction of flight of the missile. As the missile closes in on the target, the change in image size causes a change in the contrast pattern, but equally in all directions from the center of the target image. Therefore, no change in direction control is made.

The derotation prism tells the sensor and, in turn, the missile which way is up. It permits the sensing system to be insensitive to rotation of the missile.

A beam splitter is employed to send the image of the target to both the light sensor and the vidicon tube. The image of the target as seen by the sensor is also picked up by the vidicon tube, and a video broadcast is sent back to the governing aircraft.

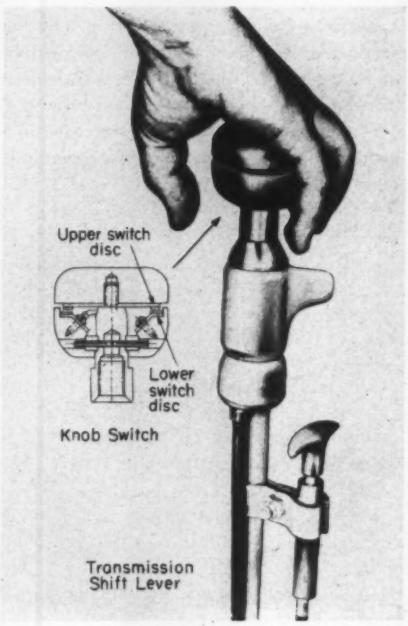
Jamming or misdirecting the control system is nearly impossible. The only possible method would be to place an optical signal source equivalent to the sensor field of view within sight of the missile and move it in a direction normal to the optical axis at a rate slow enough for the control system to follow. The jamming source would have to be located in an optical field whose total angle would be less than ½ deg.



Pressure from Engine Cooling System

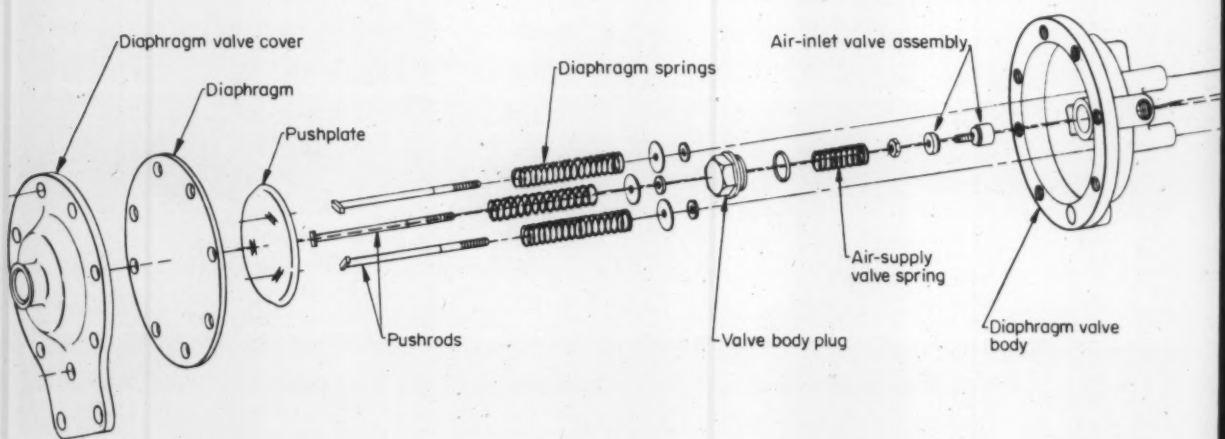
SEMIAUTOMATIC POWER TRANSMISSION in new Diamond T trucks eliminates the clutch pedal with no sacrifice in fuel economy. When the engine is idling, the clutch is automatically disengaged and the transmission can be shifted to the starting gear with the shift lever. When engine speed is increased above idling, pressure in the engine water-cooling system increases. This pressure change is sensed and used indirectly to engage the clutch. After the vehicle is moving, the clutch can be released for further shifting by an electric switch on the shift-lever knob.

The transmission, tradenamed Presto-Matic, was designed by the Dana Corp., Toledo, Ohio.

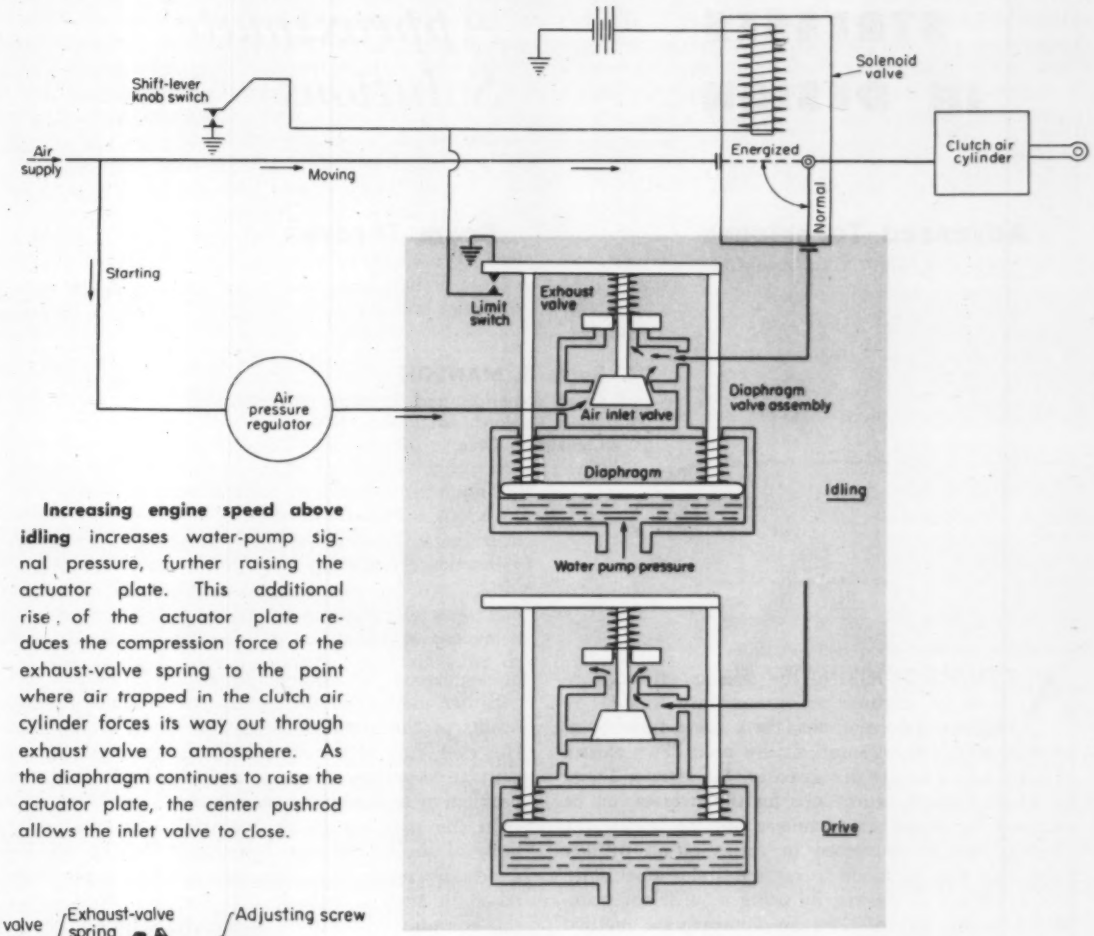


CLUTCH RELEASE OCCURS whenever pressure is applied to the piston of the clutch-control air cylinder. Air pressure reaches the cylinder through either of two circuits. A circuit marked "moving" goes directly through the solenoid valve. The other path denoted as "starting" passes through the diaphragm valve assembly and the normal position of the solenoid valve.

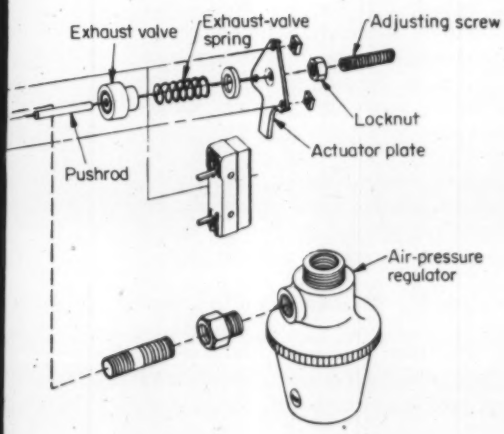
After the engine is started, hydraulic pressure from the engine-cooling-system water pump pushes the diaphragm of the diaphragm valve assembly up. Upward movement of the diaphragm, though slight, will raise the actuator plate enough to open the limit switch; this upward movement is not enough to close the air-inlet valve. Opening of the limit switch de-energizes the solenoid valve and it returns to its normal position. Air under pressure passes through the air-pressure regulator, the diaphragm-valve assembly, and the solenoid valve causing the clutch air cylinder to disengage the clutch.



Controls Drive-Clutch Engagement



Increasing engine speed above idling increases water-pump signal pressure, further raising the actuator plate. This additional rise of the actuator plate reduces the compression force of the exhaust-valve spring to the point where air trapped in the clutch air cylinder forces its way out through exhaust valve to atmosphere. As the diaphragm continues to raise the actuator plate, the center pushrod allows the inlet valve to close.



Further increases of engine speed and, in turn, water-pump pressure permit all of the clutch-cylinder air to bleed off and fully engage the clutch. Since the diaphragm valve operates as a variable pressure regulator, the clutch gradually engages in proportion to engine speed, which gives smooth vehicle starting and allows inching of vehicle.

To disengage the clutch to shift the transmission, the operator closes the shift-lever knob switch, which energizes the solenoid valve. Air pressure passes directly to the clutch air cylinder, releasing the clutch.

To re-engage the clutch, the shift-lever knob switch is opened, de-energizing the solenoid valve and cutting off the air supply. When the solenoid valve returns to its normal position, the air in the clutch cylinder exhausts through the open exhaust valve and the clutch engages.

When the vehicle slows to a stop, the diaphragm and actuator plate drop, opening the inlet valve and closing the exhaust valve, thus disengaging the clutch.

THERMAL STRESSES IN DESIGN

Part 7—Exact and Approximate Solutions

Advanced Techniques

Beam Theory

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ALTHOUGH most of the thermal-stress problems of engineering interest are treated by approximate methods, there are a number of cases in which exact solutions are used. Two classes of exact solutions are discussed in this article: Those for which explicit expressions for the stresses can be obtained in closed form, and those for which the solution can be expressed in terms of an infinite series that can be made to represent the exact solution as closely as desired by using a sufficient number of terms. In addition, an approximate method using beam theory is outlined.

In this outline of available solutions, methods as well as final formulas are emphasized, since these same methods can be applied by the designer to particular problems at hand.

As an aid to the solution of problems, final equations for the solution of thermal-stress problems which relate to certain classic body shapes are given in Table 2.

Advanced Techniques

The problem of determining the thermal stresses in a body is equivalent to that of determining the stresses in a body of similar geometry subjected to a system of surface and body forces. Alternatively, it is equivalent to the problem of solving the inhomogeneous biharmonic equation, Equation 27.[6]

Either method of setting up the problem usually results in the same mathematical detail of solution. However, one of the methods may have special advantage over the other in the visualization of the problem or in analytical procedure.

In the methods to be described, elemental solutions of the biharmonic equation which do not individually satisfy the boundary conditions are combined in such a manner that the sum does satisfy the boundary conditions. Elemental solutions themselves are easy to obtain, but the difficult aspect of the problem is to choose the proper ones and the proper combinations to satisfy the boundry conditions.

One method involves the use of the complex variable. Another method avoids complex numbers by judicious choice of the solution form, and results essentially in a Fourier expansion in both x and y variables. Other possible methods will be briefly indicated.

A rectangular plate, Fig. 49, is subjected to a temperature variation $T = T_0 (y^2 - 1/3)$ in the y-dimension only. The first step is to evaluate the stress function, from which all stresses, strains, and displacements can readily be computed. The following approaches are presumably exact if an infinite

[6]References are tabulated at end of article.

number of terms are used. In practice, results are approximate because of limitations imposed on the number of terms and because of other complications that arise during the solution.

Particular Integral: The equation to be solved is the inhomogeneous biharmonic, $\text{del}^4\phi + \text{del}^2 E\alpha T = 0$. The solution is divided into two parts, $\phi = \phi_h + \phi_p$, where ϕ_h is the solution of the homogeneous equation, and ϕ_p is a particular integral of the inhomogeneous equation (see Nomenclature).[6]

Since $\text{del}^4\phi_p + \text{del}^2 E\alpha T = 0$, which can be rewritten as $\text{del}^2 [\text{del}^2\phi_p + E\alpha T] = 0$, ϕ_p is any particular integral of the second-order differential equation $\text{del}^2\phi_p + E\alpha T = 0$. The particular integral of $\text{del}^2\phi_p + E\alpha T = 0$ can be written in the form[11]

$$\phi_p = -\frac{E\alpha}{4\pi}\int\int T(\xi\eta)\log\left[(x-\xi)^2 + (y-\eta)^2 \right] d\xi dn$$

where the integration limits for ξ and η are over the entire cross-section of the body. Although this expression yields a closed-form solution for ϕ_p in terms of x and y, the integration may be very difficult to perform unless T is a particularly convenient function. In principle, however, it is always possible to carry out the integration numerically and tabulate ϕ_p as a function of x and y. Thus, the values of the function and its normal derivation at the boundary can be established numerically, if not analytically.

Since T is an even polynomial of y only, a particular integral in the form of an even polynomial in y can be found. It is assumed that $\phi_p = Ay^4 + By^2 + C$ and A, B, and C are solved for so that $\phi_p = 0$ at $y = \pm 1$ and satisfies the equation $\text{del}^2\phi_p + E\alpha T = 0$. This results in $\phi_p = -(y^4 - 2y^2 + 1)/12$. Also, the normal derivative of ϕ_p equals zero at $y = +1$, which will be useful in establishing the boundary conditions.

HOMOGENEOUS BIHARMONIC EQUATION: Because of common occurrence in elasticity theory, the solutions of the homogeneous biharmonic equation are well known. If a solution in the form $e^{\lambda x}f(y)$ or $e^{-\lambda x}f(y)$ is assumed, substitution results in an ordinary linear differential equation for $f(y)$, for which the solutions are direct (such as $\cos \lambda y$), elemental (such as $e^{\lambda x}\cos \lambda y$), or sums and differences of elemental solutions (such as $\cosh \lambda x \cos \lambda y$). Also, since the homogeneous biharmonic equation is completely symmetrical in x and y, it is obvious that additional solutions can be formed by interchanging x and y in these expressions. Finally, any of these solutions multiplied by an arbitrary constant is also a solution. The complete solution is thus the sum of a sufficient number of independent solutions, each multiplied by a constant coefficient, such that the sum is capable of satisfying the boundary conditions.

The problem at hand requires a solution that is completely symmetrical in x and y about the origin; that is, it must remain unchanged when x is replaced by $-x$, and y by $-y$. Hence, only the even expressions such as cos, cosh, y sin, y sinh, x sin, and x sinh can appear in the solution. Replacing λ by constants α and β for convenience, the general solution is

$$\phi = -\frac{1}{12}(y^2 - 2y + 1) + \sum_{n=1}^{\infty} \cos \alpha_n y(A_n \cosh \alpha_n x + \beta_n \alpha_n x \sinh \alpha_n x) + \sum_{m=1}^{\infty} \cos \beta_m x(C_m \cosh \beta_m y + D_m \beta_m y \sin \beta_m y)$$

As far as the biharmonic equation is concerned,

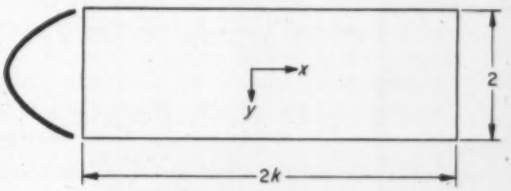


Fig. 49—Flat plate with transverse temperature variation $T=T_o\ [y^2-(1/3)]$. No temperature variation in axial direction

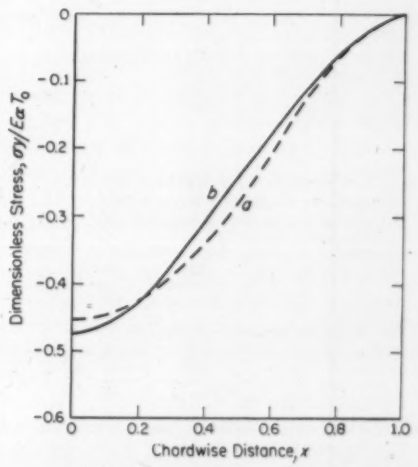


Fig. 50—Transverse stress at end of plate. Comparison shows *a*, method of collocations using three stations, and *b*, eigenfunctions using two eigenvalues and least squares. Chordwise distance is measured from centerline *y*

A_n, β_n, α_n, C_m, D_m, and β_m are completely arbitrary. The specific choice of these constants must be determined to satisfy the boundary conditions.

SATISFYING THE BOUNDARY CONDITIONS: One procedure for evaluation of constants to satisfy boundary conditions makes use of a boundary loading problem, not one of thermal stress.[12] Even though this approach makes use of the equilibrium and compatibility equations, rather than the equivalent biharmonic equation, the basic procedure can be used for the problem under discussion. However, it is recognized that because of the differences involved, the resulting analytical expressions will have different forms.

The first boundary condition to be satisfied is $\partial\phi/\partial y = 0$ at $y = \pm 1$. Since the expression for ϕ is even in y, it is only necessary to satisfy the condition at $y = 1$. Now $d\phi p/dy = 0$ at $y = 1$; the y derivative of the expression under the first summation sign can be made zero at $y = 1$ for all values of a_n, if $a_n = n\pi$, where n is any integer, and the y derivative of the expression under the second summation sign can be made to vanish if the y derivative inside the bracket is set equal to zero. The procedure for satisfying the boundary condition $\partial\phi/\partial x = 0$ at $x = b$ is identical to the procedure followed in satisfying the boundary condition at $y = 1$.

Table 2—Equations for Classic Body Shapes

Flat Plate with Circular Boundary: When the temperature is a function of the disc radius, the disc thickness constant, and the disc solid, the equations[7] for the radial and tangential stresses are

$$\sigma_r = \alpha E \left(\frac{1}{b^2} \int_0^b Trdr - \frac{1}{r^2} \int_0^r Trdr \right)$$

and

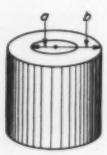
$$\sigma_t = \alpha E \left(-T + \frac{1}{b^2} \int_0^b Trdr + \frac{1}{r^2} \int_0^r Trdr \right)$$

If the disc has a hole at $r = a$, the equations become

$$\sigma_r = \frac{\alpha E}{r^2} \left(\frac{r^2 - a^2}{b^2 - a^2} \int_a^b Trdr - \int_0^r Trdr \right)$$

and

$$\sigma_t = \frac{\alpha E}{r^2} \left(\frac{r^2 - a^2}{b^2 - a^2} \int_a^b Trdr + \int_a^b Trdr - Tr^2 \right)$$



Cylinders with Radial Temperature Variation: When a solid circular cylinder is constrained, the axial stress[8] is

$$\sigma_z = \frac{\alpha E}{1 - \mu} \left(\frac{2\mu}{b^2} \int_0^b Trdr - T \right)$$

If the ends are free to expand,

$$\sigma_z = \frac{\alpha E}{1 - \mu} \left(\frac{2}{b^2} \int_0^b Trdr - T \right)$$

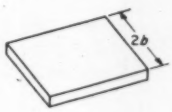
When the cylinder has a concentric hole, the axial stress for complete constraint is

$$\sigma_z = \frac{E\alpha}{1 - \mu} \left(\frac{2\mu}{b^2 - a^2} \int_a^b Trdr - T \right)$$

and, for free ends

$$\sigma_z = \frac{E\alpha}{1 - \mu} \left(\frac{2}{b^2 - a^2} \int_a^b Trdr - T \right)$$

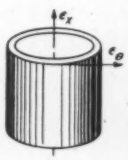
Flat Plates of Rectangular Contour: In most cases these problems do not lend themselves to closed-form solution and problems of this nature will be discussed in connection with advanced and various approximate methods. However, for long plates in which the temperature varies only along the short dimension,



$$\sigma_x = E\alpha \left(-T + \frac{1}{2b} \int_{-b}^b Tdy + \frac{y}{2b^3} \int_{-b}^b Tydy \right) \quad (35)$$

where $2b$ = height of the plate and y = distance measured from the center of the plate. This formula is valid only at distances removed from the end of the plate.

Thin Cylindrical Shell: If there is axial temperature variation, the final result in this case can become quite complicated depending on the precise temperature variation. The solution of the stress problem hinges on the solution of the differential equation,



$$\frac{d^4w}{dx^4} + 4w = -4R\alpha T$$

where w = radial displacement of a point on the middle surface of the shell, x = ratio of the axial co-ordinate of the shell to the characteristic length, $l = (R^2H^2)/3(1 - \mu^2)^{1/4}$, R = mean radius, and H = thickness of the shell.

If the temperature T is taken in the form of a simple polynomial, sinusoidal, or exponential function, the solution of this differential equation offers no difficulty. It consists of the solution of the homogeneous equation and a particular integral, which can be taken in the same form as that of the temperature function.

With this method, the final expression for ϕ is

$$\phi = -\frac{1}{12}(y^2 - 2y + 1) + \sum_{n=1}^{\infty} B_n \cos \alpha_n y[\alpha_n x \sinh \alpha_n x - \cosh \alpha_n x(b\,\alpha_n \coth b\,\alpha_n + 1) + \sum_{m=1}^{\infty} D_m \cos \beta_m x[\beta_m y \sinh \beta_n y - \cosh \beta_m y(\beta_m \coth \beta_n + 1)]$$

where α and β are constants.

When the boundary condition $\phi = 0$ at $y = 1$ is written down, an expression is obtained which contains all the B_n and C_m terms. By multiplying through by $\cos \beta_m x$ and integrating between the limits $x = \pm b$, all but one of the D terms cancel and it becomes possible to solve for D_m in terms of the B coefficients only. Similarly, in satisfying the boundary condition $\phi = 0$ at $x = 0$, the multiplier $\cos \alpha_n y$, and integration between $y = \pm 1$ results in an explicit equation for B_n in terms of all the D's.

Hence, when $z = y/a$,

$$\phi_p = -\frac{1}{12}(y^4 - 2y^2 + 1) + \frac{\sinh \pi n \dfrac{b}{a} \displaystyle\int_{-1}^{+1} \phi_p(z) \cos \pi n z\, dz}{\pi n \dfrac{b}{a} + \dfrac{1}{2} \sinh 2\pi n \dfrac{b}{a}}$$

Values for D_m and B_n are obtained by using a limited number of terms and setting up simultaneous equations for D_m in terms of all prior values of B_n and B_n in terms of all prior values of D_m.[12] In the end problem, the use of relatively few terms gave good results, but in the thermal stress problem, as treated here, a large number of terms are required, and the approach can become cumbersome.

Methods Involving Complex Variables: Other advanced methods have been applied to the solution of thermal-stress problems, in most cases involving the use of the complex variable. In the eigenfunction approach to the solution, when only even functions of y are involved, the solution is assumed in the form,

$$\phi = \phi_p + F_n \sum e^{-\lambda_n x}(\cos \lambda_n y + G_n y \sin \lambda_n y) \qquad (36)$$

so that all the elemental solutions under the summation sign satisfy the homogeneous biharmonic equation.[13,14,15] Application of the boundary conditions $\phi = \partial\phi/\partial y = 0$ at $y = 1$ results in the characteristic equation for λ,

$$\sin 2\lambda_n + 2\lambda_n = 0$$

and the coefficient $G_n = -\cot \lambda_n$.

Thus, the values that λ_n can assume become those that satisfy Equation 36. Each root is called an eigenvalue, and the function is called an eigenfunction. An infinite number of such roots exist, but only a limited number have been determined. All the roots are complex, and occur in groups. Depending on the physical nature of the particular problem, it may be possible to limit consideration to only the first quadrant and adjust the real part of the solution to take into account the effect of the other pairwise roots.

The coefficients F_n in Equation 36 are chosen to satisfy other boundary conditions of the problem. Unfortunately, there are no exact methods for determining these coefficients, except in very special cases.[13] In practice, a limited number of roots λ_n are considered, and the coefficients for the eigenfunctions determined by a least squares or colloca-

Once the complete solution is obtained, the components of strain can be determined from

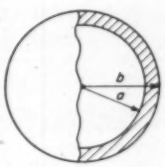
$$\varepsilon_z = \mu \frac{w}{R} - \frac{1}{l^2} \frac{d^2 w}{dx^2} z + (1 + \mu)\alpha T$$

$$\varepsilon_\theta = -\frac{w}{R}$$

$$\varepsilon_z = -\frac{\mu}{1 - \mu}(\varepsilon_x + \varepsilon_\theta) + \frac{1 + \mu}{1 - \mu} \alpha T$$

where z is the radial co-ordinate of the shell measured from the middle surface, and ε_x and ε_θ are the axial and tangential strains. The stresses can be determined from the strains by the Hooke's law relations.

Spheres with Radial Temperature: Although the stresses in this case are three-dimensional, the problem becomes one of two dimensions, since two of the stresses are equal by symmetry. For the solid sphere of radius b, the radial and tangential stresses[10] are



$$\sigma_r = \frac{2E\alpha}{1 - \mu}\left(\frac{1}{b^3}\int_0^b Tr^2 dr - \frac{1}{b^3}\int_0^r Tr^2 dr\right)$$

and

$$\sigma_t = \frac{E\alpha}{1 - \mu}\left(\frac{2}{b^3}\int_0^b Tr^2 dr + \frac{1}{r^3}\int_0^r Tr^2 dr - T\right)$$

For the hollow sphere of inner radius a and outer radius b the stresses are

$$\sigma_r = \frac{2E\alpha}{1 - \mu}\left(\frac{r^3 + a^3}{b^3 - a^3} r^3 \int_a^b Tr^2 dr - \frac{1}{r^3}\int_a^r Tr^2 dr\right)$$

and

$$\sigma_t = \frac{2E\alpha}{1 - \mu}\left[\frac{2r^3 + a^3}{2(b^3 - a^3)} r^3 \int_a^b Tr^2 dr + \frac{1}{2r^3}\int_a^r Tr^2 dr - \frac{1}{2}T\right]$$

tion procedure.[15] Collocations, as a general method for solving the biharmonic equation, will be discussed in a later section.

Fig. 50 shows some results of computations in which a least-squares procedure was used to establish the constants F_n, where only two terms were used to solve an idealized problem representing the thermal stresses in a turbine bucket.[12] Also, a comparison with a collocation procedure for directly solving the equivalent problem set up as an inhomogeneous biharmonic equation is shown.

Conformal mapping and application of the Fourier integral are two other methods which have been applied to thermal-stress problems. Both involve the use of complex variables. In the conformal mapping technique, a complicated geometrical shape is transformed into a simpler configuration by the use of a complex transformation variable. One example of the method treats the case of a cylinder with an eccentric hole by mapping it into two concentric cylinders.[16]

The Fourier integral technique is similar to the series technique just described in connection with the eigenfunction method, except that the summation considered is an integral instead of the infinite summation. This method has been used to study thermal stresses in rectangular strips.[13,14]

Comments on Advanced Exact Methods: Although the methods just outlined are exact in that each of the elemental solutions satisfies the biharmonic equation, and the exact solution can presumably be obtained by the superposition of a sufficient number of these solutions, they are approximate when practical considerations are injected into the problem of satisfying the boundary conditions. The calculations become cumbersome, particularly in the methods involving the application of roots of transcendental equations and complicated combinations of complex numbers.

In practice, therefore, the results obtained become no more accurate, and in many cases much less accurate, than approximate methods later to be discussed. One reason for this is that, while the form of solution is such that the differential equation is always satisfied, the degree to which the boundary conditions are satisfied, depends markedly on the number of terms used. Unless many terms are used, adherence to the boundary conditions may be very poor.

On the other hand, it is the boundary conditions, rather than the biharmonic equation, that have the most influential effect in defining the specific nature of a given elasticity problem. Hence, superior results may be obtained by methods in which the assumed solutions are such that the boundary conditions are exactly satisfied, while adherence to the differential equation at all points is compromised by limitations in the number of terms used.

Beam Theory

One of the most useful characteristics of the

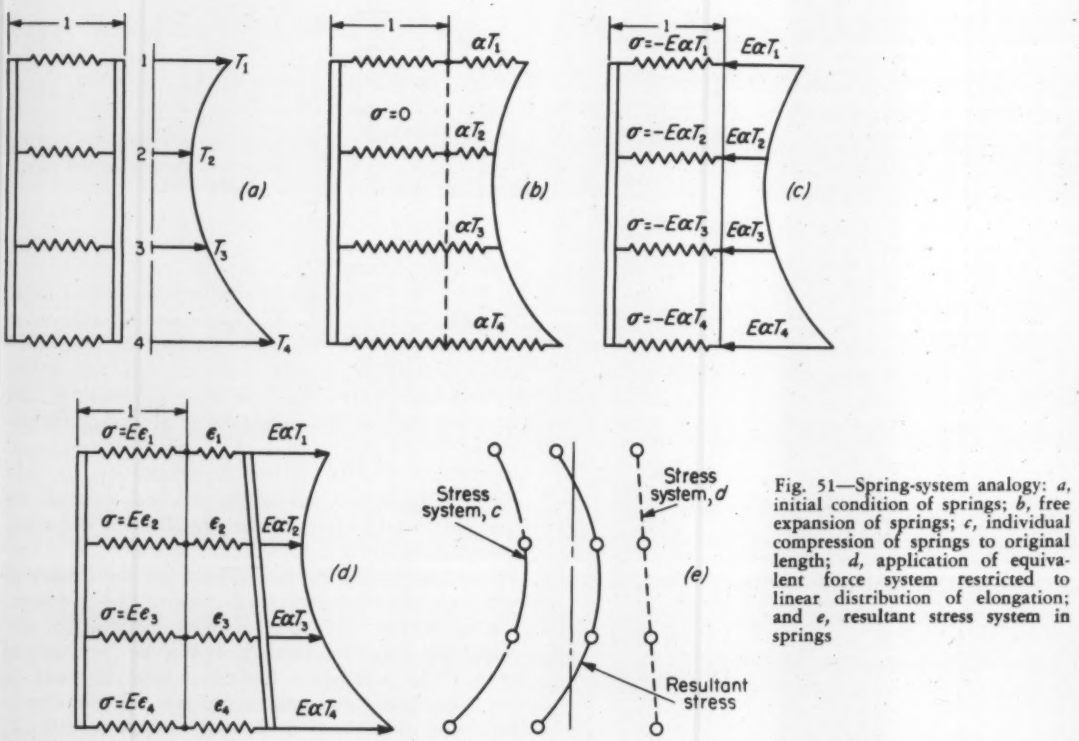


Fig. 51—Spring-system analogy: *a*, initial condition of springs; *b*, free expansion of springs; *c*, individual compression of springs to original length; *d*, application of equivalent force system restricted to linear distribution of elongation; and *e*, resultant stress system in springs

formulation approach, whereby the thermal-stress problem is replaced by an equivalent surface and body force problem, is that simplifications may occur in the mathematics of solution. In addition, a physical concept of the equivalent loading system can be gained. A striking example of this type of application is the use of beam theory.

When $S = (P/A) + (Mc/I)$ is applied to determine the stress in the outermost fiber of a beam subjected to axial load P and bending moment M, this formula is not rigorously correct according to the strict theory of elasticity. In place of compatibility equations, the assumption that plane sections remain plane is introduced. The change in orientation of adjacent planes establishes the strain distribution, in terms of relatively few unknown constants, which in turn establishes the stress distribution. The actual magnitudes of the stresses are then determined by applying a few pertinent equilibrium equations to establish the unknown constants.

Despite the simplicity of the assumption, and the simplifications in analyses that result, the beam theory results in very accurate stress analysis for bodies which are long in comparison with any cross-sectional dimension, and for sections relatively far from the ends of the beam or points of concentrated load applications.

Performance of beam theory is pointed out by examination of the equation,[17]

$$\sigma_x = \frac{P}{A} + \frac{My}{I} + \frac{d^2M}{dx^2}\left[\frac{1}{2}\left(\frac{y}{c}\right)^3 - \frac{3}{10}\left(\frac{y}{c}\right)\right] + \text{terms containing only fourth and higher derivatives of } M \qquad (37)$$

where P/A = net axial load divided by cross-sectional area = average axial stress, and My/I = bending stress at distance y from the centroid of beam.

If M is constant or varies linearly along the beam, the conventional formula gives exact results. If M contains powers of x of greater than 2, error is introduced. However, if the bending moment varies gradually, as is usually the case except in the immediate vicinity of concentrated loads, the error is usually small, since it depends only on higher order derivatives of M.

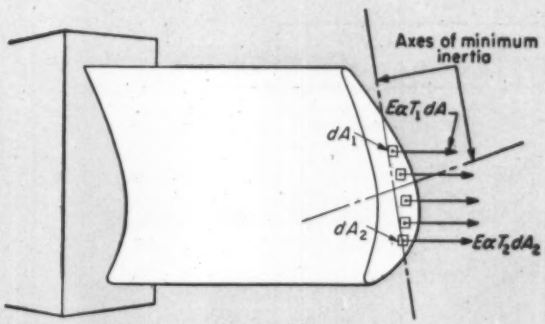


Fig. 52—Force distribution at end of beam. Temperature varies in cross section but is constant along lengths

Since the thermal-stress problem can be replaced by equivalent surface and body forces, the proportions of the body involved are such that it can be considered as a beam. The stresses are then approximated by determining the net force and moment on any section along the beam. There may be small errors which depend on second and higher-order derivatives of temperature along the beam, but these are usually small if the temperature varies slowly in the axial direction. Thus, the equivalent force and moment are determined, and the corrections are considered.

Beam with No Axial Temperature Variation: Examples using spring systems, which presumably change length when the temperature is changed, show the application of beam theory and use of Duhamel's analogy.

Any elastic system can be regarded as an equivalent system of discrete masses and springs, each element having a spring constant E. For the present, cross-sensitivity due to Poisson's ratio is neglected. Four long springs are assumed connected at their ends by rigid straight bars, Fig. 51. When the temperature is at a reference value of zero, all the springs are of identical length. The temperature of each spring is then individually increased according to the distribution shown in Fig. 51*a*. If the connecting bar on the right side of the springs is temporarily removed, the springs expand freely to new lengths, Fig. 51*b*. Stresses in all the springs, in this position, are zero.

However, this cannot be the final condition of the spring system, since the ends on the right cannot be joined by a straight rod, as initially assumed, without some further straining of the springs.

To obtain this required condition, each spring is brought back to its initial length by application of a suitable external force, $-E\alpha T$, Fig. 51c. The resulting stress in each spring is $-E\alpha T$.

After the springs are compressed and joined by the straight bar, the external compressive forces are removed. The springs extend to some new position, as yet unknown, but subject to the limitation that their ends lie on a straight line. In order to determine the position and orientation on the right side of the bar, an alternate problem is used which yields an identical solution. Consider the system of springs in their initial condition prior to any increases in temperature. Both ends are attached to rigid straight bars. If forces of equal magnitude but opposite sign to these of Fig. 51*b* are applied to the bar at the right, the bar assumes a position such that the restraining forces of the springs $E\varepsilon_1$, $E\varepsilon_2$, $E\varepsilon_3$, and $E\varepsilon_4$ are in equilibrium with the applied forces $E\alpha T_1$, $E\alpha T_2$, $E\alpha T_3$, and $E\alpha T_4$, Fig. 51*d*. Thus, they have the same net force and moment. The problem is readily solved since ε_1, ε_2, ε_3, and ε_4 are linearly related.

However, this problem is identical to that of determining the stress distribution in a beam: The stresses must be determined so as to resist a known resultant force, and a known resultant moment, while maintaining a linear distribution of strain. The stress system shown by the dotted line, Fig. 51*e*, indicates stress distribution in the springs resulting from the externally applied loading system. However, before the external load system was applied, Fig. 51*c*, the springs already had an internal stress system. Thus these stress systems must be added in order to obtain the resultant stress system, Fig. 51*e*.

By direct analogy, the following procedure is used for determining the stress distribution in a beam, which does not have temperature variations along its length, but which may have arbitrary temperature distribution in the cross sectional plane, Fig. 52.

1. Divide the cross-sectional area into a number of elemental areas and apply at the end of each element an external elemental load, $E\alpha T dA$. Determine the net force and moments about the two principal axes of inertia resulting from the stress system.

2. At any point having distances y_1 and z_1 from the principal axes of inertia, the beam stresses due to force systems are

$$\sigma' = \frac{1}{A}\int_A E\alpha T dA + \frac{y_1}{I_y}\int_A E\alpha T y dA + \frac{z_1}{I_z}\int_A E\alpha T z dA \qquad (38)$$

3. Subtract from σ' the stress $\sigma'' = E\alpha T$, where T is the temperature at the local point, to obtain the local stress σ. Thus,

$$\sigma = \sigma' - \sigma'' \qquad (39)$$

The results are valid only in planes removed some distance from the ends of the beam. At the ends of the beam the net axial stresses must approach zero.

The foregoing analysis is applicable only when bending displacements associated with the stress system σ' and axial displacements associated with the stress system σ' are permitted to occur freely. If the boundary conditions are such as to prevent these displacements, or to introduce arbitrary displacements, the necessary stresses to induce the supplementary deflections must be added to the stress system σ.

Beam with Axial Temperature Variation: When the temperature varies axially, each axial element must be replaced by a series of springs at a different temperature, Fig. 53. To return each spring to its undistributed length requires the distributed external loading system shown. These forces are such that the net force on the nth spring is $-E\alpha T_n$, where T_n is the temperature of the nth spring. This set of forces corresponds to the distributed body force system $-E\alpha\partial T/\partial x$ and the surface forces $E\alpha T$ in the case of an elastic continuum.

It is necessary to determine the superimposed stress system resulting from removal of the distributed load system. The sum of all such externally applied forces on the uppermost row of springs is

$$E\alpha[(T_4 - T_3) + (T_3 - T_2) + (T_2 - T_1) + T_1] = E\alpha T_4$$

Similarly, the net value of all the forces on the second row of springs is $E\alpha T_9$, and that on the third row of springs is $E\alpha T_{14}$. The net forces involved depend only on the temperatures in the plane under consideration. Hence, a problem in which the temperature varies along the beam can be treated in exactly the same manner as one in which the temperature remains constant along the length, except that in determining the stresses in a given section, the temperatures in that section only are used in Equations 38 and 39.

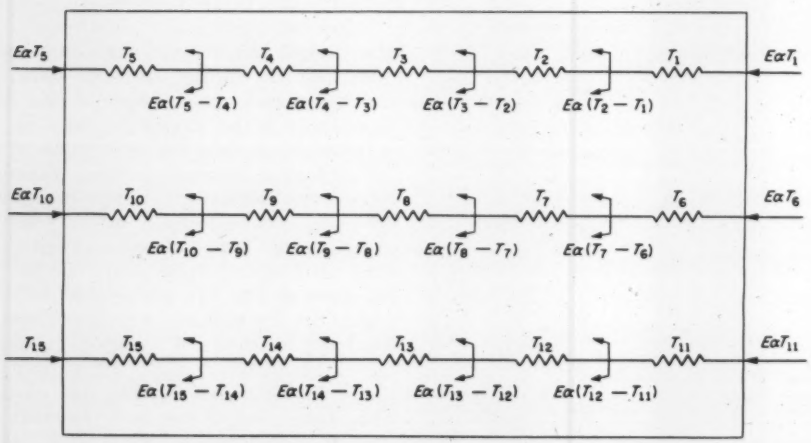


Fig. 53—Spring analogy for temperature variation along beam axes

Beam with Three-Dimensional Temperature Variation: A first approximation to the solution of the problem when the temperature in a long body varies in all three dimensions is obtained by using Duhamel's analogy.

To obtain the stress in the axial or x direction, the body is assumed to be a beam, Fig. 54. The net force and bending moment in the plane PP is first determined. Considering the forces distributed along the element ΔA by x_1, the net force is

$$E\alpha\Delta A\left[-T(o, y_m, z_m) - \int_0^l \frac{\partial T}{\partial x}\,dx\right]$$

$$= E\alpha\Delta A[-T(o, y_m, z_m) -$$

$$T(x_1, y_m, z_m) + T(o, y_m, z_m)]$$

$$= -E\alpha\Delta A[T(o, y_m, z_m)]$$

Thus, the net effect of the end traction and the distributed body force system is a single force, related only to the temperature at the cross section under consideration, regardless of the temperature variation in the span x_1.

Consider next a transverse element ΔA_1. The net force across this element is

$$E\alpha\Delta A_1[T(x_n, o, z_n) - T(x_n, o, z_n) +$$

$$T(x_n, b, z_n) - T(x_n, b, z_n) = 0$$

In a similar manner a transverse element in the z-direction produces a zero net force.

It is concluded, therefore, that a simplified beam analysis yields a net force and moment at any section PP, which is the same whether or not the temperature varies in the axial direction. The temperature distribution used must be the temperature in the plane under consideration. Otherwise, Equations 38 and 39 apply for the most general case of temperature variations.

In the next article, the solution of thermal-stress problems by using energy methods will be outlined.

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This article is the seventh in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" ... June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" ..... August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959

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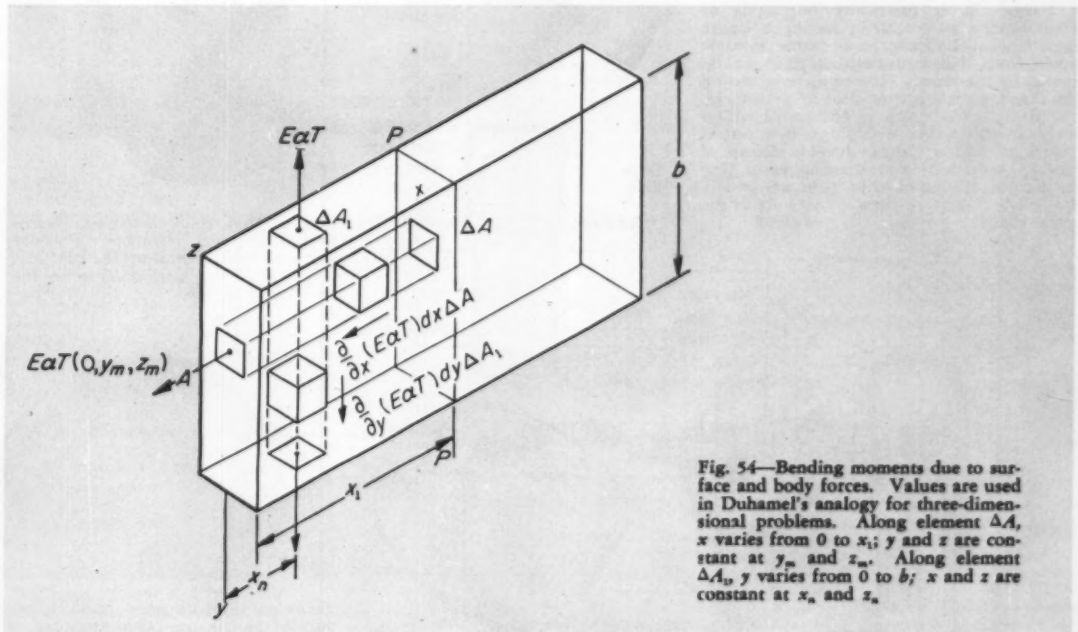


Fig. 54—Bending moments due to surface and body forces. Values are used in Duhamel's analogy for three-dimensional problems. Along element ΔA, x varies from 0 to x_1; y and z are constant at y_m and z_m. Along element ΔA_1, y varies from 0 to b; x and z are constant at x_n and z_n

BASIC HYDROFORM PARTS

VARIABLE-DEPTH PARTS

RE-ENTRANT OPENINGS

MULTIPLE-FORMING TECHNIQUES

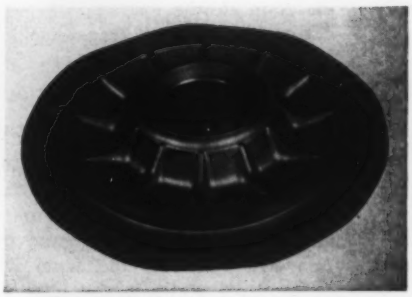
HYDROFORMING DIFFICULT SHAPES

By RICHARD PAULTON
Chief Engineer
Meta-Dynamics Div.
The Cincinnati Milling Machine Co.
Cincinnati, Ohio

HYDROFORMING is an economical means of forming small quantities of simple or complex shapes in sheet metal.* Tooling can be adapted to produce re-entrant openings, extra-deep drawn components, and similar "difficult" pieces.

This article shows how these parts are produced by adapting basic Hydroform tooling.

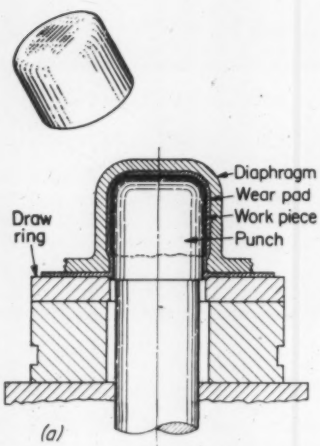
*J. R. Zimmerman—"Hydroforming," MACHINE DESIGN, Vol. 29, No. 13, June 27, 1957, p. 86.

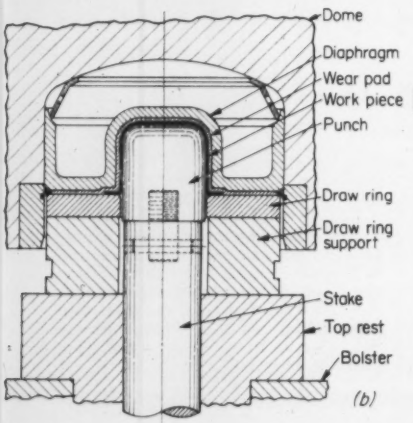


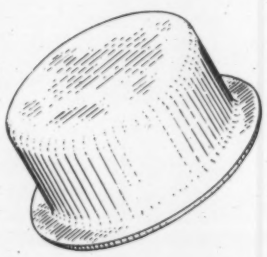
Automotive hub cap, 0.030-in. stainless steel, Hydroformed in one draw

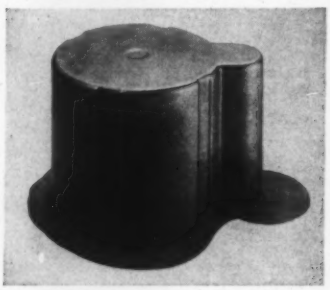
BASIC HYDROFORM PARTS

A punch and parallel-face draw ring are the basic tools for Hydroforming, *a*. This type of tooling produces a cup-shaped part with a flange. It is practically impossible to Hydroform a part without having a flange remain, *b*. The flange is desirable in some applications, but for others, it must be removed by trimming. Flow of material during the drawing cycle is controlled by pressure on the flange. Too much means part breakage and too little causes wrinkling. If a part is pulled without a flange, there is danger of cutting wear pads and diaphragms, *a*. For small parts, flanges of $\frac{3}{8}$ to $\frac{1}{2}$ in. are usually sufficient. On large parts, $\frac{1}{2}$ to 1 in. is the usual range.

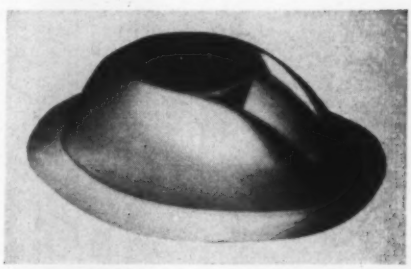








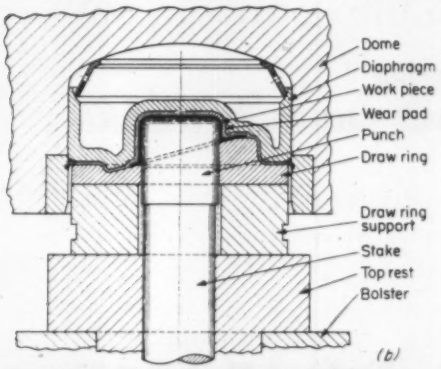
Can, 0.034-in. cold-rolled steel, Hydroformed in one operation. Previous method required drawing the can, cutting a wall slot, and welding on the protruding section

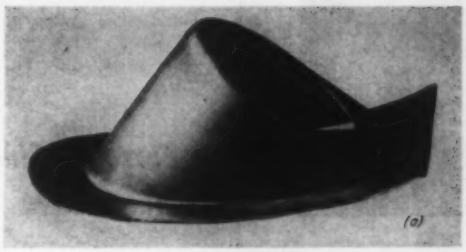


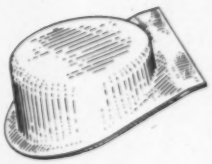
Reflector, 0.041-in. aluminum, Hydroformed in one operation compared to three press operations formerly needed

VARIABLE-DEPTH PARTS

By use of a contoured draw ring, variable-depth parts, or parts with a shaped flange, can be produced, *a*. Note variation of flange area with depth of draw, *b*.



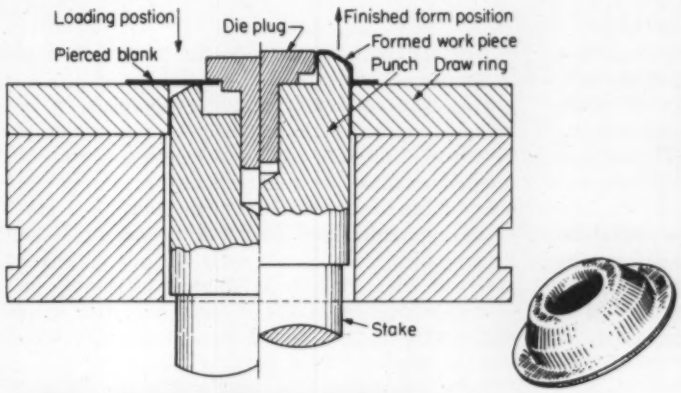


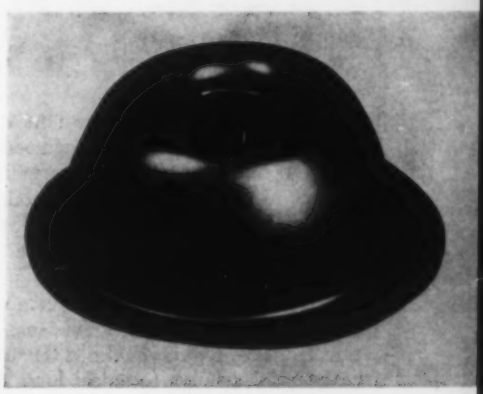


Aircraft part, 0.037-in. aluminum, Hydroformed and trimmed in two operations. Previous production required six drop-hammer operations

RE-ENTRANT OPENINGS

Die plugs, used in combination with a pierced blank, produce formed parts with re-entrant openings.



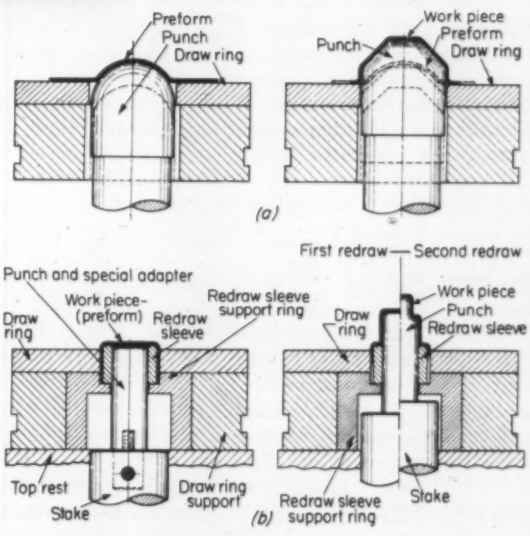


Air-cleaner cover, 0.025-in. 1020 steel, Hydroformed in one operation. Conventional methods require multiple operations

MULTIPLE-FORMING TECHNIQUES

One of the simplest of the multiple-forming operations is preforming, a method used to start a normally difficult job. Basically, this involves forming a shape to partial depth of the finished part, *a*. When this preform is put on the final-form punch, it is wrapped onto the upper portion of the punch by diaphragm pressure with no drawing action. Punch movement then completes the draw.

Preforms and multiple Hydroforming operations can be combined to produce more complex parts, *b*. Occasionally, sizing or ironing in a draw is used to hold closer tolerances or radii than are normally necessary. Sizing of inside or outside dimensions is accomplished with a sizing ring in a second operation after the draw has been completed. Diaphragm pressure drives the ring over the critical diameter to size and set the part.



Jet engine part, 0.043-in. AMS 5540 steel, Hydroformed by redrawing a preformed cup. Conventional forming methods require welding of two stamped sections

The Personal Side of Engineering

By **EDWIN C. NEVIS** Personnel Research and Development Corp., Cleveland, Ohio

The Technical Talent Hunt

WITH a business upturn in 1959, the widespread demand for engineering talent will continue. Organizations will try all kinds of ways to entice, recruit, and retain qualified engineering personnel. And companies will continue to search for better ways to utilize their technical people.

For instance, more and more companies will delegate routine activity to technicians. This frees the scarcer, more highly qualified engineer to handle the critical, complex technical jobs. But, perhaps as a result of established programs, technicians have already become scarce. Even now, personnel men have trouble recruiting sufficient numbers to handle the available jobs.

An interesting solution to this problem is an engineering development program at the Naval Air Station, San Diego, Calif., reported by Robert Eaton and Stanley Peterson.* The program is designed to obtain adequate personnel for the station's engineering requirements. The plan develops sufficient trained people to meet immediate engineering needs from among civilian nonengineer air-station personnel.

With the co-operation of San Diego State College in establishing a 5-year program involving work and study, the program was announced to the 7500 civilians employed at the station. Of the 300 who applied for the program, 40 passed an admission test, and 23 were finally selected for the program.

These 23 finalists had college-entrance test scores in the upper ten per cent of all students enrolled at the college! Obvious implication: Rather than spending a great deal of time and money in recruiting from without, organizations might do well to look at their own personnel for talent that might be trained.

This is a potentially valuable approach—a fact brought out rather dramatically in a study by the Personnel Research and Development Corp. The company studied ran into difficulty recruiting engineers. It decided to make a pilot study of a group of its apprentice-level mechanical workers. If sufficient talent were found, various kinds of training programs could then be established to provide necessary engineering skills. It was felt that special engineering courses would provide enough know-how to handle routine technical assignments.

Some 329 apprentices were evaluated. About 40 were found to be superior on scholastic-aptitude scores, which are generally highly indicative of success in college. In other words, some 12 per cent of the group had sufficient intelligence and mechanical aptitude to warrant consideration for a complete engineering program leading to a degree. Some of these individuals, incidentally, did not complete high school.

It would appear that the search for engineering talent—particularly for people who can spell engineers on the more routine aspects of their job—might be turned to the personnel already employed in an organization. The value of taking people who are familiar with the company's operation is great in terms of speed with which training may be put to use. Persons singled out for training often react very favorably to the opportunities provided.

While the cost of such training may seem high, when compared with the costs of recruiting technician-level personnel it may be quite nominal. This is especially true if it is only necessary to train for specific, limited skills rather than for a full engineering background.

*Journal of the American Society of Training Directors, Sept., 1958.

Methods for plotting and calculating

Disc-Cam Curvature

from instantaneous values of follower position, velocity, and acceleration

By J. HIRSCHHORN
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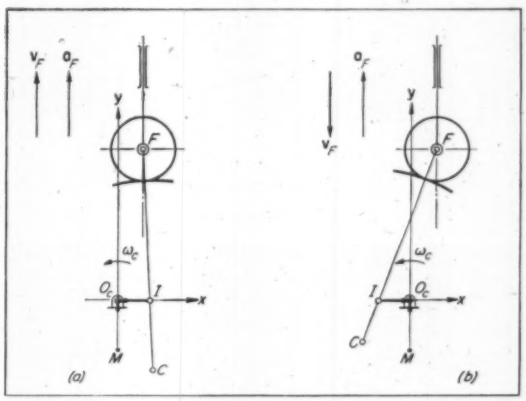


Fig. 1—Disc cam and reciprocating roller follower. Velocity of follower at *b* is identical in magnitude but opposite in direction to that at *a*

Nomenclature

a = Acceleration, in. per sec^2
$_ca$ = Coriolis acceleration component, in. per sec^2
$_na$ = Normal component of acceleration, in. per sec^2
$_ta$ = Tangential component of acceleration, in. per sec^2
a_r = Reduced value of follower acceleration, in.
l = Follower lift, in.
r_b = Base radius of cam, in.
r_c = Instantaneous radius of curvature of cam profile, in.
r_f = Radius of roller follower, in.
v = Velocity, in. per sec
v_r = Reduced value of follower velocity, in.
α_f = Angular acceleration of follower, rad per sec^2
θ_0 = Minimum angle between line of centers and follower face, deg
λ = Angular lift of follower, deg
ϕ = Face angle of flat-faced follower, deg
ω_c = Angular velocity of cam, rad per sec
ω_f = Angular velocity of follower arm, rad per sec

INSTANTANEOUS radius of curvature of any point on the surface of a disc cam can be readily found by straightforward methods of kinematic analysis. This article presents graphical and analytical techniques of curvature determination for four follower arrangements:

1. Reciprocating roller follower
2. Reciprocating flat-faced follower
3. Oscillating roller follower
4. Oscillating flat-faced follower

Graphical procedures for these four systems are summarized in Table 1. Step-by-step construction details and equations for exact curvature solutions are given in the following discussion. Symbols are defined in Nomenclature and Table 1.

Reciprocating Roller Follower

Graphical Solution: A disc cam driving a reciprocating roller follower and the equivalent slider-crank mechanism are shown in the top line of Table 1. Instantaneous values of velocity, acceleration, and curvature are determined by the following constructions, as illustrated in the table.

FOLLOWER VELOCITY: Through center of cam rotation, O_c, draw line perpendicular to line of stroke, intersecting connecting-rod line FC, or its extension, at point I.

Triangle CIO_c is similar to the velocity diagram for the mechanism but "out-of-phase" 90 deg in the "sense" of cam rotation. Relationship of triangle sides corresponds to solution of the vector equation

$$v_C = v_{CF} + v_F$$

where v_C and v_F are absolute velocities of points C and F, respectively and v_{CF} is the velocity of point C relative to point F.

Scale factor of diagram is cam angular velocity ω_c, giving $v_F = \omega_c\,[IO_c]$, $v_C = \omega_c\,[CO_c]$, and $v_{CF} = \omega_c\,[CI]$.

Velocity direction is found by rotating corresponding sides of triangle 90 deg against cam rotation.

FOLLOWER ACCELERATION (RITTERHAUS' CONSTRUCTION): Through point I of velocity diagram, draw line parallel to line FO_c, intersecting line $O_c C$, or its extension, at point K. Through K draw line perpendicular to line of stroke, intersecting line FC or its extension at point L.

Through L draw line perpendicular to line FC and through O_c draw line parallel to line of stroke, intersecting line from point L at point M.

Quadrilateral $CLMO_c$ is similar in all respects (shape and position) to the acceleration polygon for the mechanism. It represents the solution to the vector equation

$$\mathbf{a}_C = {}_n\mathbf{a}_{CF} + {}_t\mathbf{a}_{CF} + \mathbf{a}_F$$

Scale factor of polygon is ω_c^2, giving $a_F = \omega_c^2[MO_c]$, $a_C = \omega_c^2[CO_c]$, ${}_na_{CF} = \omega_c^2[CL]$, and ${}_ta_{CF} = \omega_c^2[LM]$. In Table 1, direction of the various accelerations is indicated by arrows.

CAM CURVATURE: Position of follower center F relative to center of cam rotation O_c and quantities v_F, a_F, and ω_c are now known.

Locate points F and O_c to scale. Find point I using the "reduced" velocity vector $v_r = v_F/\omega_c$; with arrowhead at point O_c, rotate vector 90 deg from v_F in the sense of cam rotation.

Locate point M by positioning reduced acceleration vector $a_r = a_F/\omega_c^2$ with arrowhead at O_c. Retrace steps in Ritterhaus' construction of acceleration polygon to find point K.

Find center of curvature C at intersection of lines $O_c K$ and FI.

Analytical Solution: Locate point I with reduced velocity vector as in previous graphical solution. Distance FC from follower center to center of cam curvature is:

$$FC = r_f + r_c = \frac{[(o + v_r)^2 + d^2]^{1.5}}{(o + 2v_r)(o + v_r) + d(d - a_r)} \qquad (1)$$

In this expression, distances d and o are always positive, while v_r and a_r can be either positive or negative depending on the position of the arrowhead in the co-ordinate system shown in Table 1.

If the position of the follower is specified in terms of lift (displacement from lowest point of follower travel), distance d can be found from

$$d = [r_b + r_f)^2 - o^2]^{1/2} + l \qquad (2)$$

Example: A disc cam actuates a roller follower which reciprocates in vertical guides, Fig. 1*a*. Find the instantaneous radius of curvature where ω_c = 150 rad per sec, o = 0.375 in., r_f = 0.5 in., r_b = 1.25 in., l = 0.625 in. v_F = 75 in. per sec, and a_F = 18,000 in. per sec^2.

Reduced velocity $v_r = -75/150 = -0.500$ in. This value is negative because "vector" IO_c has a negative direction.

Reduced acceleration a_r = 18,000/22,500 = 0.8 in. This value is positive because "vector" MO_c has a positive direction.

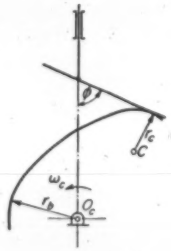
From Equation 2, d = 2.334 in., and from Equation 1, $r_f + r_c$ = 3.492 in. Thus, r_c = 2.992 in.

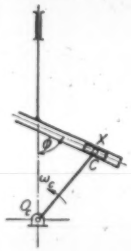
If direction of v_F were reversed, Fig. 1*b*, with

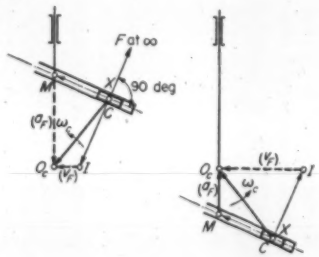
Table 1—Graphical Solution of Disc-Cam Curvature

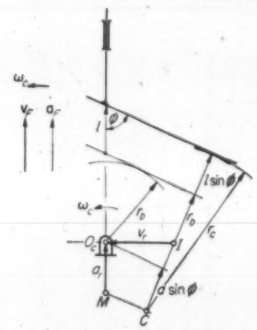
Basic System	Equivalent Mechanism	Velocity and Acceleration	Cam Curvature
Reciprocating Roller Follower			

Reciprocating Flat-Faced Follower

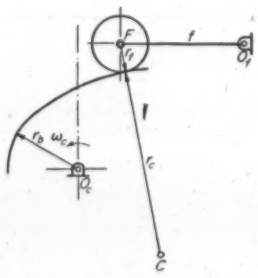


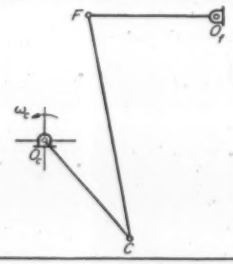


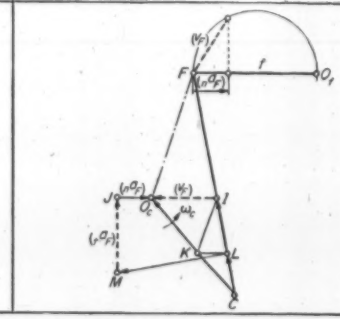


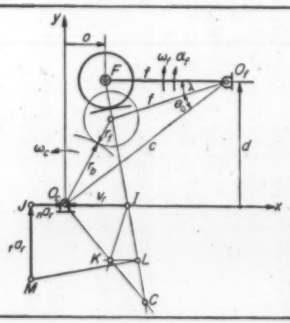


Oscillating Roller Follower

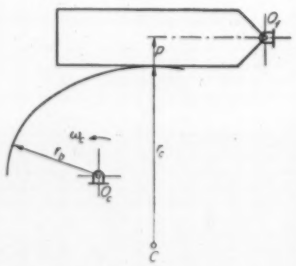


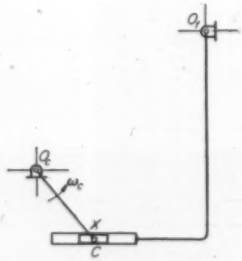


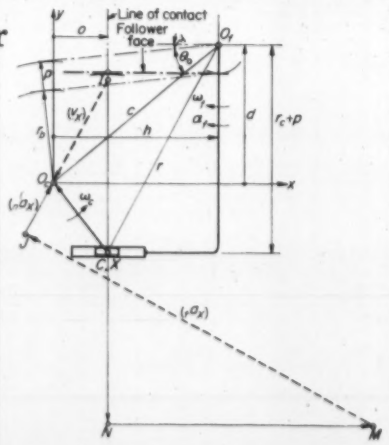




Oscillating Flat-Faced Follower







other conditions remaining the same, $d = 2.334$ in. and $r_c = 2.738$ in.

Reciprocating Flat-Faced Follower

Graphical Solution: Analysis of a disc cam with reciprocating flat-faced follower is shown on the second line of Table 1. In the construction of the equivalent double-slider mechanism, point *X*, which is located on the follower, coincides with "crankpin" *C* at the particular instant under consideration. Motion of point *X* is representative of follower motion which is translatory.

As compared to the roller-follower system, point *F* (center of roller) is at infinity in a direction perpendicular to follower face, simplifying velocity and acceleration analysis considerably.

FOLLOWER VELOCITY: Find velocity diagram by same procedure as for roller follower. Here, $v_F = v_X = \omega_c[IO_c]$, $v_C = \omega_c[CO_c]$, and $v_{CX} = \omega_c[CI]$. Rotate sides of triangle 90 deg against cam rotation to determine correct vector directions.

FOLLOWER ACCELERATION: Use same procedure as for roller follower. Note that points *K* and *L* coincide with point *C*. Relationships are: $a_F = a_X = \omega_c^2[MO_c]$, $a_C = \omega_c^2[CO_c]$, and $a_{CX} = \omega_c^2[CM]$.

CAM CURVATURE: Locate points *I* and *M* as for roller follower. Draw line through point *I* perpendicular to follower face. Draw line through point *M* parallel to follower face. Intersection of these two lines is required center of curvature.

Analytical Solution: Locate point *I*, as before, using reduced velocity vector. Then,

$$r_c = r_b + (l + a_r)\sin\phi \qquad (3)$$

where ϕ is the face angle of the follower. For a flat-faced "in-line" follower, $\phi = 90$ deg. In Equation 3, distance r_b and l are always positive while a_r is considered positive for an "outward" direction of acceleration.

Oscillating Roller Follower

Graphical Solution: Analysis of a disc cam with an oscillating roller follower is shown on the third line of Table 1.

FOLLOWER VELOCITY: Through O_c, draw line parallel to follower arm, intersecting line *FC*, or its extension, at point *I*. As in the construction for the reciprocating follower arrangements, triangle CIO_c is similar to the velocity diagram for the mechanism but out-of-phase 90 deg in the sense of cam rotation. Scale factor again is ω_c and velocity of the roller center, $v_F = \omega_c[IO_c]$. Angular velocity of the follower arm, $\omega_f = v_F/f$.

FOLLOWER ACCELERATION: This solution is based on a modified form of the previous Ritterhaus' construction to allow for the normal acceleration of roller center *F*. Through *I* draw line parallel to FO_c, intersecting line O_cC, or its extension at point *K*. Through *K* draw line parallel to follower arm intersecting connecting rod line *FC*, or its extension, at point *L*. Through *L* draw line perpendicular to line *FC*.

Locate point *J* by extending line IO_c the length of the reduced normal acceleration vector for point *F*. This length $JO_c = {}_na_r = [IO_c]^2/f = v_r^2/f$. Vector direction is toward O_c. Through *J* draw line perpendicular to follower arm, intersecting line from point *L* at point *M*.

Polygon $CLMJO_c$ is similar in all respects to the acceleration polygon of the mechanism, corresponding to the vector equation

$$\mathbf{a}_C = {}_n\mathbf{a}_{CF} + {}_t\mathbf{a}_{CF} + {}_t\mathbf{a}_F + {}_n\mathbf{a}_F$$

Scale factor again is ω_c^2, giving ${}_ta_F = \omega_c^2[MJ]$. Angular acceleration of follower arm is $\alpha_f = {}_ta_F/f$.

CAM CURVATURE: On scale plot of points *F*, O_f, and O_c, locate point *I*, as in previous construction, with reduced velocity vector $v_r = v_F/\omega_c = (f\omega_f)/\omega_c$.

Locate point *J* by positioning reduced normal acceleration vector for follower, ${}_na_r = v_r^2/f$, parallel to line FO_f with arrowhead at point O_c and directed toward O_f. Locate point *M* by positioning reduced tangential acceleration vector for follower, ${}_ta_r = (f\alpha_f)/\omega_c^2$, with arrowhead at point *J* and direction according to convention.

Retrace steps of modified Ritterhaus' construction to locate point *K*. Intersection of lines *FI* and O_cK is the required center of curvature.

Analytical Solution: Locate point *I* with reduced velocity vector as in previous graphical solution. Distance *FC* between roller center and center of cam curvature is;

$$FC = r_f + r_c = \frac{[(o + v_r)^2 + d^2]^{1.5}}{(o + v_r)(o + 2v_r - {}_na_r) + d(d - {}_ta_r)} \qquad (4)$$

In this expression d is always positive, while o can be either positive or negative according to the position of point *F* in the co-ordinate system shown in Table 1. Quantities v_r, ${}_na_r$, and ${}_ta_r$ can also be either positive or negative depending on their direction in relation to the co-ordinate system convention.

If follower position is specified in terms of angular lift from minimum point of travel, then o and d may be calculated from

$$o = c\cos(\theta_0 + \lambda) - f \qquad (5)$$

$$d = c\sin(\theta_0 + \lambda) \qquad (6)$$

where

$$\cos\theta_0 = \frac{c^2 + f^2 - (r_b + r_f)^2}{2cf} \qquad (7)$$

Example: Find instantaneous radius of curvature for disc cam with oscillating roller follower, Fig. 2, where $\omega_c = 150$ rad per sec, $r_b = 1.5$ in., $c = 4$ in., $f = 3$ in., $r_f = 0.5$ in., $\lambda = 25$ deg, $\omega_f = 25$ rad per sec, $\alpha_f = 6000$ rad per sec^2.

From Equation 7, $\cos\theta_0 = 0.875$, giving $\theta_0 = 28$ deg 57 min. From Equation 5, $o = -0.646$ in. From Equation 6, $d = 3.234$ in.

Reduced velocity $v_r = -0.5$ in. ("vector" IO_c has negative direction). Reduced acceleration components are ${}_na_r = 0.083$ in. (vector JO_c points in positive direction) and ${}_ta_r = 0.800$ in. (vector *MJ* points in positive direction).

From Equation 4 then, $r_f + r_c = 4.101$ in., and $r_c = 3.601$ in.

Oscillating Flat-Faced Follower

Graphical Solution: This analysis appears on the bottom line of Table 1. Point *X*, which is on the follower, coincides with crankpin *C* at the particular instant under investigation. Since the follower is rotating, acceleration of point *C* relative to point *X* has a Coriolis component, ${}_ca_{CX}$. Magnitude of this component is:

$$ {}_ca_{CX} = 2\, v_{CX}\, \omega_f $$

FOLLOWER VELOCITY: Through point O_c draw line parallel to $O_f C$, intersecting "line of contact" at *I* to give triangular velocity diagram as in previous constructions. Here, angular velocity of follower arm $\omega_f = v_X/r = \omega_c[IO_c]/r$ where *r* is distance $O_f X$.

FOLLOWER ACCELERATION: Along the line of contact, starting from point *C*, lay off reduced Coriolis component of acceleration $CN = {}_ca_r = 2[CI](\omega_f/\omega_c)$. Direction of this vector is away from *I* if ω_c and ω_f are opposite in sense (Table 1), toward *I* if these velocities have same sense.

Through point *N*, draw line perpendicular to "line of contact"; that is, parallel to follower face. Find point *J* as in construction for roller follower, using reduced normal acceleration vector for follower, $JO_c = {}_na_r = [IO_c]^2/r = v_r^2/r$. Vector direction is toward O_f. Through point *J*, draw line perpendicular to line $O_f X$, intersecting line through point *N* at point *M*.

Polygon $CNMJO_c$ is similar in all respects to the mechanism acceleration diagram, corresponding to the vector equation,

$$ \mathbf{a}_C = {}_c\mathbf{a}_{CX} \twoheadrightarrow {}_s\mathbf{a}_{CX} \twoheadrightarrow {}_t\mathbf{a}_X \twoheadrightarrow {}_n\mathbf{a}_X $$

where ${}_s\mathbf{a}_{CX}$ is the component of $\mathbf{a}_{CX}$ along the slot. Scale factor again is ω_c^2.

Tangential acceleration ${}_ta_X = \omega_c^2[MJ]$ and angular acceleration of the follower arm $\alpha_f = [MJ]\omega_c^2/r$.

CAM CURVATURE: For this type of cam-follower system, the graphical method of curvature determination is lengthy and cumbersome, and offers no advantages over the analytical approach. It will be omitted here.

Analytical solution: Find the position (distance *o*) of the line of contact in relation to point O_c from

$$ o = -\frac{h\omega_f}{\omega_c - \omega_f} \tag{8} $$

Calculate instantaneous radius of curvature from

$$ r_c + p = \frac{d\omega_c(\omega_c - 2\omega_f) + \alpha_f(h - o)}{(\omega_c - \omega_f)^2} \tag{9} $$

In Equations 8 and 9, ω_c, *h*, and *d* are always positive. Angular velocity ω_f is considered positive if it has same sense as ω_c, and α_f is taken as positive if it imparts to the contact point a positive (outward) tangential acceleration.

If position of follower is specified in terms of angular lift, *h* and *d* may be determined from

$$ h = c\cos(\theta_0 + \lambda) \tag{10} $$

$$ d = c\sin(\theta_0 + \lambda) \tag{11} $$

where

$$ \sin\theta_0 = \frac{r_b + p}{c} \tag{12} $$

Example: Find the instantaneous radius of curvature of a disc cam with a flat-faced oscillating follower, Fig. 3*a*, where $\omega_c = 150$ rad per sec, $r_b = 1.5$ in., $c = 4$ in., $\omega_f = 25$ rad per sec, $\alpha_f = 6000$ rad per sec^2, $p = 0.5$ in., and $\lambda = 25$ deg.

From Equation 12, $\sin\theta_0 = 0.5$, giving $\theta_0 = 30$ deg. From Equations 10 and 11, $h = 2.294$ in. and $d = 3.277$ in. From Equation 8, then, $o = 0.328$ in. Angular velocity ω_f is taken as negative because its sense is opposite to ω_c.

From Equation 9, $r_c + p = 3.595$ in., giving $r_c = 3.095$ in. In this calculation, α_f was considered positive because an outward tangential acceleration is being imparted to the contact point.

If, in the previous example, the sense of ω_f is reversed, Fig. 3*b*, $h = 2.294$ in., $d = 3.277$ in., $o = -0.459$ in. (line of contact is on opposite side of O_c), and $r_c = 3.422$ in.

ACKNOWLEDGMENT

This article is based on a paper presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

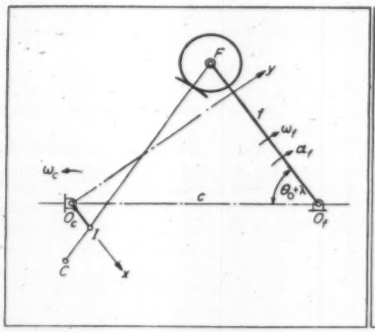


Fig. 2—Disc cam and oscillating roller follower

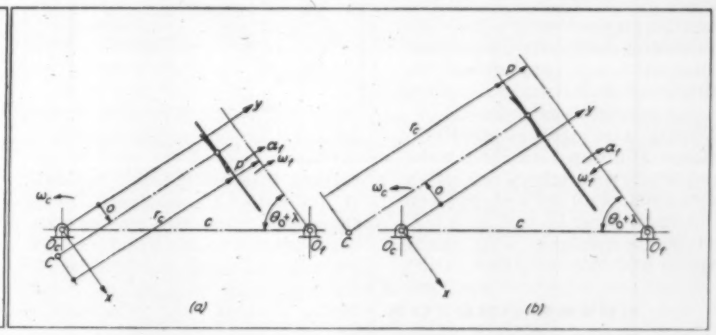


Fig. 3—Disc cam and oscillating flat-faced follower. Angular velocity of follower arm at *b* is equal in magnitude but opposite in sense to that at *a*

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ENGINEERING NEWS

Space-Saver Toggle Gives Big Switch Performance

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Circle 475 on Page 19

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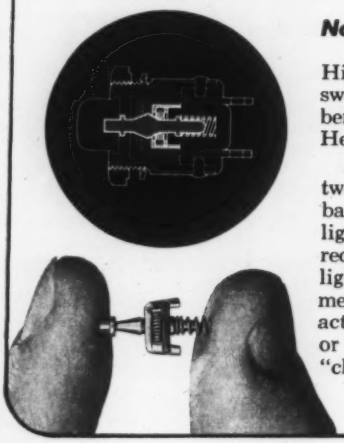

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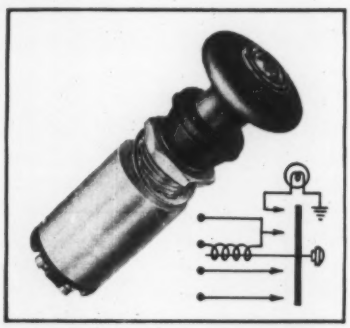
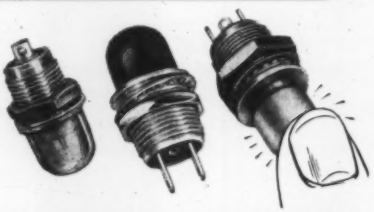


Circle 476 on Page 19



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DESIGN ABSTRACTS

mechanical

Lateral Vibrations In Reciprocating Machinery

C. M. Lowell, Worthington Corp.

Experimental findings dealing with lateral shaft vibrations of reciprocating machinery which point out a coupling between torsional and lateral vibration. Definitions of forward and reverse whirl, and methods of observing and measuring them, are described. Conclusions indicate that torsional disturbances can cause lateral vibration in a shaft system, and that an overhung flywheel is particularly susceptible to this phenomenon because of its relatively low lateral natural frequency. Equations yield natural-frequency values close to actual values. Preliminary calculations of torsional natural frequency, torque-variation frequency, and lateral natural frequency, permit shaft and flywheel sizes to be chosen so that torsional disturbance frequencies and lateral whirling frequency can be separated sufficiently to insure against excitation of lateral vibration.

ASME paper 58-A-79, ASME Annual Meeting, New York, December, 1958; 13 pp.

Effects of Surface Finish On Journal-Bearing Load Capacity

F. W. Ocvirk and G. B. DuBois, Cornell University

A proposed criterion for determining the limit of hydrodynamic lubrication based on the magnitude of roughness of surface finishes of journal and bearing. Perfect alignment of the journal and bearing is assumed, and only surface roughness is considered. Design curves give the load capacity of a bearing corresponding to a minimum film thickness limited by the irregularity of a given surface finish. The form of plotting shows the influence of clearance ratio and minimum film thickness on load capacities. It also shows the influence of clearance and film thickness on journal and bearing friction and conditions for minimum friction. Equations are rearranged to give a form of plotting which emphasizes clearance and the minimum film thickness rather than eccentricity ratio. In heavily loaded bearings, changes in eccentricity ratio are small for large changes in loads whereas changes in minimum film thickness are relatively greater.

ASME paper 58-A-34, ASME Annual Meeting, New York, December, 1958; 8 pp.

Theory of High-Pressure Bourdon Tubes

W. Wuest, Aerodynamics Research Institute, Goettingen, Germany

Mathematical treatment of stresses and deformations in thick-walled tubes of the Bourdon type. Stress conditions in straight tubes of flat-oval cross-section are covered, and a circular cross-section is treated as a special case. The law of deflection of such tubes is included.

ASME paper 58-A-119, ASME Annual Meeting, New York, December, 1958; 21 pp.

Pressurized and Air-Lubricated High-Speed Journal Bearings

N. F. Rieger, University of Nottingham

A study of the friction characteristics of an externally pressurized air-lubricated journal bearing. Effects of variation in speed, load, diametral clearance, and inlet pressure over a wide speed range are included. Experimental friction coefficients are compared with those given by the Petroff formula, and a reasonable degree of correlation is shown. Bearing air consumption is measured and a linear relationship between air mass flow and inlet pressure is indicated. Curves relating load-carrying capacity to various ratios of inlet pressures are included. Bearings are plain, cylindrical bushings 1⅜ in. in diameter and 1½ in. long.

The Institution of Mechanical Engineers (Great Britain), meeting of the Lubrication Group, February, 1959; 10 pp.

electrical

An Acceleration Switching Servo

S. A. Murtaugh Jr., Cornell Aeronautical Laboratory

A new concept in electrohydraulic control which represents a different approach to the design of electrohydraulic closed-loop control systems. The usual hydraulic servomechanism design uses a dc amplifier and a flow-control servo valve to obtain hydraulic flow proportional to the position or velocity error of the load. With the new acceleration switching servo, these components are replaced by an electronic multivibrator and a specially designed electrohydraulic-servo valve called an acceleration switching valve. System control is obtained through modulation of the multivibrator dwell time by which the driven-load acceleration is regulated.

The servo valve behaves as a pure integrator throughout most of its operating frequency range. This new technique results in increased reliability, excellent servo-valve resolution, negligible center-shift due to temperature extremes, and near-infinite pressure-gain characteristics. The switching servo is especially valuable where the control is required to respond to small input signals and/or operate in an environment of temperature extremes or contaminated fluid.

ASME paper 58-A-159, ASME Annual Meeting, New York, December, 1958; 6 pp.

techniques

Synthesis of Path-Generating Mechanisms by Digital Computer

F. Freudenstein, Columbia University and G. N. Sandor, Springdale Laboratories Div.

A general method for synthesizing plane, link mechanisms obtainable from a single, closed kinematic chain. Methods are applied to four-link mechanisms for generating a path through up to five arbitrary points with prescribed corresponding crank rotations. The five-point synthesis is programmed for automatic computations which determine all existing solutions (a maximum of twelve linkages), selects one on the basis of a quality index, and computes the generated path. The general single-loop chain is investigated and results applied to four-bar mechanisms. In this approach, complex-number representation of coplanar vectors is well suited and is used for obtaining prescribed velocities and accelerations.

ASME paper 58-A-85, ASME Annual Meeting, New York, December, 1958; 9 pp.

Designing to Reduce Down Time

D. I. Dumond, The Cross Co.

Three criteria by which designers may judge their designs relative to required maintenance. General aspects of simplicity, interchangeability, and flexibility as applied to machine components are considered. Examples of "perishable" and "semi-durable" components are analyzed for maintenance frequency. Design techniques involving placement of oil seals, limit switches, solenoid-operated valves, and placement of locating pins are covered. Case histories showing design for ease of maintenance are illustrated. Emphasis is on simplicity and interchangeability in design, but advantages of modular construction show the necessity for including flexibility as well.

ASME paper 58-A-131, ASME Annual Meeting, New York, December, 1958; 4 pp.

Analyzing Torsional Vibration In Diesel Engines

A. B. Hamilton, General Motors Corp.

Applications of the electromechanical analogy concepts which allow a mechanical system to be thought of in terms of electrical circuit theory. This technique permits torsional vibration data to be obtained without running a full-scale test engine. Considerable time and effort is saved compared to using a purely analytical approach. In practice, a torsional system is idealized as a network of concentrated inertias, pure torsional springs, and pure viscous damping elements. An electrical model of the torsional systems is then arranged in accordance with the schematic arrangement of the mechanical system. Voltages obtained by this method are added vectorially with known engine torque configuration to provide stress data at various points in the torsional system.

General Motors Engineering Journal, Vol. 5, No. 4, October-November-December, 1958; pp. 2-6.

Stress Analysis Techniques For Improving Casting Designs

L. H. Ravitch, General Motors Corp.

Fundamental concepts of strain measurement using the brittle-lacquer and strain-gage methods. Brief case histories show redesign of castings resulting from data obtained by the two methods. A brief guide to good casting design shows some do's and don'ts concerning fillets and radii, wall thickness, ribs, and brackets.

General Motors Engineering Journal, Vol. 5, No. 4, October-November-December, 1958; pp. 22-27.

Application of Statistics to Dimensioning of Machine Parts

M. F. Spotts, Northwestern University

How to maintain tolerances tight enough to insure proper functioning of machine parts yet loose enough to satisfy production. Bilateral tolerances are recommended rather than unilateral tolerances for shop drawings, and statistical aspects of dimensioning are considered. Formulas show how to determine the number of production mating parts that will and will not fit. Examples show how to dimension clearance fits, how to dimension assemblies when standard deviations are unknown, and how to dimension for overlapping tolerances. The method involves a normal distribution curve showing the frequency of occurence of an error versus its magnitude. A table of areas under portions of the curve gives values to substitute in the equations for particular dimensioning problems.

ASME paper 58-A-44, ASME Annual Meeting, New York, December, 1958; 6 pp.

A General Approach to The Solution of Creep Problems

A. Mendelson, M. H. Hirschberg, and S. S. Manson, NASA

A practical solution of creep problems by successive approximation. The method is applicable to different creep laws and loading paths. Illustrative examples include the simple case of creep in a flat plate under a temperature gradient and several cases of creep in rotating discs. Transient conditions prior to the establishment of steady-state stress distribution have an appreciable effect on total creep strains. The general method involves computing plastic flow in plates, cylinders, and spheres by successive approximation. Solution begins with obtaining plastic strains which are used to calculate new stress and total strain distribution. Better approximation to the plastic strains can then be computed, and this procedure is continued until convergence is obtained.

ASME paper 58-A-98, ASME Annual Meeting, New York, December, 1958; 10 pp.

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The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W. 1.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

General Motors Engineering Journal—GM Technical Center, Box 177, North End Station, Detroit 2, Mich.

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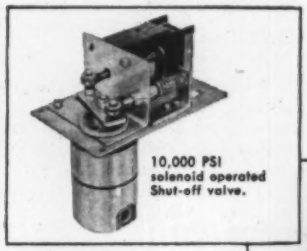

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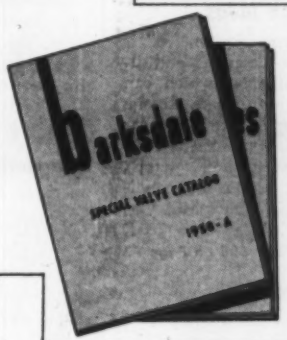

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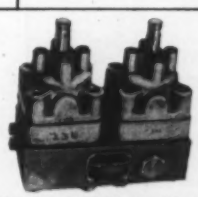

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Helpful Literature

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Hydraulic Components

Specifications, performance data, and dimensional drawings on hydraulic gear pumps, hydraulic gear motors, and hydraulic valves are included in series of data sheets. Ratings and parts lists are also among contents. Hein-Werner Corp., Industrial Div., Waukesha, Wis. K

Circle 601 on Page 19

Thermosetting Phenolics

Wide variety of products which can be made from Plenco phenolic molding compounds, phenolic industrial resins, melamine, and other modified phenolic thermosets are described and illustrated in this brochure. 16 pages. Plastics Engineering Co., Sheboygan, Wis. K

Circle 602 on Page 19

Ceramic Products

Technical information intended to aid designers in determining which engineered ceramic material is best suited for existing applications is found in "Design Handbook & Manufacturer's Catalog." Mechanical, electrical, and environmental characteristics of the materials are given. Sections are devoted to high aluminas and Steatite, as well as metalizing of ceramics. 16 pages. Globe-Union Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 603 on Page 19

Wear Resistant Alloys

Five cobalt base and iron base wear resistant alloys for investment casting are described in Bulletin F-30,132 as being suited for extreme conditions of wear, heat, and abrasion. Chemical, physical, and mechanical properties are included, along with joining, machining, grinding, and heat treating data. 8 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 604 on Page 19

Wire & Cable Jacketing

"Extrusion for Wire and Cable" is a booklet devoted to the extrusion of Alathon polyethylene resin, Rulan flame-retardant plastics, and Zytel nylon resins and their use as insulating and jacketing materials. Design of extrusion equipment and wire coating equipment is detailed. A trouble-shooting chart is also included. 16 pages. E. I. du Pont de Nemours & Co., Wilmington 98, Del. C

Circle 605 on Page 19

Ductile Irons

Booklet "Engineering Properties of Ni-Resist Ductile Irons" offers data on properties affecting design, general characteristics, heat treatment, recommended industrial applications, and mechanical, physical, and high temperature properties. A number of graphs and tables are included. Material itself offers high strength, toughness, corrosion resistance, and heat and wear resistance. 28 pages. International Nickel Co., 67 Wall St., New York 5, N. Y. C

Circle 606 on Page 19

Notching Units

Dimensions, capacities, shut heights, and die heights of Strippit notching units for notching sheet materials up to 1/8 in. (mild steel) are found in illustrated Catalog N. It covers 90-degree corner, louver, edge, and fulcrum notching for angles. Standardized edge notching units made with standard stock punch bodies, punch caps, and die holder are described. 8 pages. Wales-Strippit, Inc., 216 S. Buell Rd., Akron, N. Y. N

Circle 607 on Page 19

Plant Modernization Ideas

"59 Ideas for Modernization in '59" is title of booklet which describes and illustrates types of equipment which can bring many operations up to date. Among products are ball mill, betatron, car shaker, compressors, dielectric heaters, lift trucks, load-center substation, pumps, screens, rotary switch, and water conditioners. 20 pages. Allis-Chalmers Mfg. Co., Box 512, Milwaukee 1, Wis. K

Circle 608 on Page 19

Power Lube Systems

Line of lubricant application equipment, fittings, and accessories is described in illustrated Catalog 81. Automatic centralized systems, and semiautomatic and manual methods of lubricating machines are covered. They can be applied to any machine with a bearing surface requiring a lubricant. 32 pages. Lincoln Engineering Co., 5736 Natural Bridge Ave., St. Louis 20, Mo. I

Circle 609 on Page 19

Swing Joints

Specifications and illustrations of bronze, steel, Monel, and aluminum swing joints are content of Catalog F-8. All have ball bearing joints and maximum temperature rating of 225° F. Service instructions, available styles, and recommendations for specific liquids are included. 12 pages. OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 610 on Page 19

Air & Hydraulic Valves

Manual, electrical, mechanical, and pilot actuated types of Hi-Cyclic air and hydraulic control valves are described in illustrated catalog. NPT sizes from 1/8 to 1 in. are included, and specifications are given. 8 pages. Beckett-Harcum Co., 985 W. Locust St., Wilmington, Ohio. G

Circle 611 on Page 19

Copper-Base Alloys

Properties, forms, and composition of wrought copper and copper-base alloys are listed in detail in illustrated booklet. Nominal composition, available forms, and physical properties are given; along with tensile, yield, and shear strength; elongation of hard and soft alloys; and fabricating properties. 14 pages. Olin Mathieson Chemical Corp., Western Metals Div., East Alton, Ill. I

Circle 612 on Page 19

Heavy Duty Pumps

Available with helical gear reductions, the line of heavy duty pumps is described in Data Sheet SP-488 as having 35, 50, 90, and 150-gpm nominal ratings. The pumps are offered in five gear reductions. Maximum pressure is 200 psi on lubricating liquids. 2 pages. Viking Pump Co., Cedar Falls, Iowa. I

Circle 613 on Page 19

Magnetic Starters

Three Star line of alternating current magnetic starters in NEMA Sizes 0 to 4 for both reversing and nonreversing single-phase and squirrel-cage motors is subject of illustrated booklet "A Masterpiece." Component units are detailed and application, rating, and dimension data are also covered. 16 pages. Cutler-Hammer Inc., 328 N. 12th St., Milwaukee 1, Wis. K

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Welded Steel Tubing

Smoothweld steel tubing designed for brazed or soldering piping systems is described in illustrated folder. Its advantages are outlined. Available sizes range from 1/4 to 3 in. 4 pages. Standard Tube Co., 24450 Plymouth Rd., Detroit 39, Mich. H

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Gas Regulators

Flow and pressure specifications for a line of cylinder, manifold, and station gas pressure regulators are presented in illustrated Booklet ADC 705F. Inlet and outlet connection dimensions are given, and adapters, station valves, flowmeters, hose connections, and pressure gages are described. 36 pages. Air Reduction Sales Co., 150 E. 42nd St., New York 17, N. Y. D

Circle 616 on Page 19

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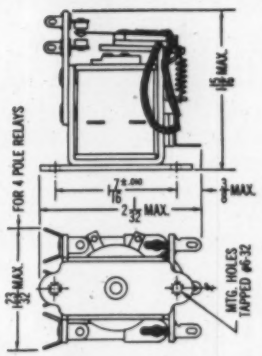

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Temperature Range: −45°C. to +85°C.

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Approx. 78% of nominal ac voltage.

Terminals: Pierced solder lugs for two #20 AWG wires.

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CONTACTS: Arrangements: up to 4 pdt.

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Load: 5 amps @ 115 volts, 60 cycle resistive loads.

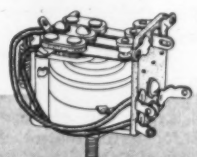
COILS: Resistance: 60,500 ohms max.

Power: 100 milliwatts per movable arm.

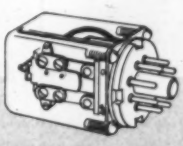
Duty: Continuous; coils will withstand 6 watts @ 25°C.

Voltages: up to 110 volts dc.
up to 230 volts ac.

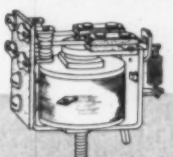
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



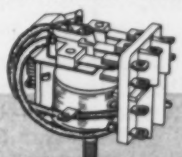
KR SERIES: SMALL, 5 AMP RELAY
Ruggedly constructed for long life and dependability. Available up to 3 pdt.



KCP SERIES: SENSITIVE 3 PDT RELAY
For plate circuit applications requiring low cost, sensitive relay. Polyethylene dust cover.



KT SERIES: ANTENNA RELAY
Insulated to minimize RF losses. Designed to switch 500 watts RF input to 300 ohm line.



KA SERIES: GENERAL PURPOSE
Compact, light-duty relay. U/L approved. Meets 1500 volts rms breakdown requirement.

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

YOU insure

RUGGED FIELD PERFORMANCE *plus* PRODUCTION SAVINGS

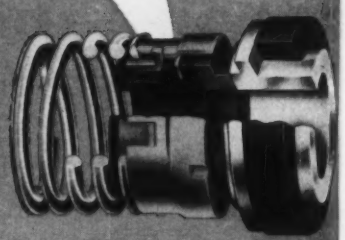
when you specify these

JOHN CRANE **MECHANICAL SEALS**

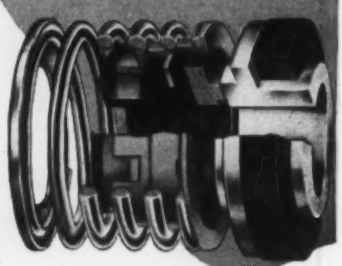
"JOHN CRANE" Types 1 and 2 shaft seals come pre-assembled. They are quickly and easily installed. Tolerances need not be critical due to the self-adjusting seal head. This is accomplished through special construction of the synthetic rubber bellows head. Moving freely under spring and hydraulic pressure, it automatically compensates for shaft end play, as well as washer wear.

Sealing faces are precision-lapped to prevent stuffing box leakage. No break-in runs necessary. Positive drive feature eliminates all stress on bellows. This feature also permits the use of light spring load to minimize wear on sealing faces. Seal needs no attention over long periods of operation.

Recommended for water, oil and other services non-injurious to synthetic rubber. Pressures to 200 psi. Temperatures: −40° to +212°F.



Type 1. For stuffing boxes of limited diameter.



Type 2. For stuffing boxes of limited length.

Above seals also available in balanced construction (1-B, 2-B) for pressures up to 500 psi.*

Write for Bulletin S-213-1

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

CRANE PACKING COMPANY

HELPFUL LITERATURE

Shaft Seals

Mechanical seals which stop leakage of gas and liquids from around the rotating shafts of pumps, compressors, mixers, etc., are described and illustrated in Catalog Section 50674. No adjusting, repacking, or maintenance is required. Specifications are given. 4 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 617 on Page 19

Fuel Shut-Off Valves

Technical features and specifications of a series of fuel shut-off valves are found in Catalog 58-A Section B. Manual, motor, and solenoid operated types are included, as is application information. 8 pages. General Controls Co., 801 Allen Ave., Glendale 1, Calif. L

Circle 618 on Page 19

Selsyn

Model A selsyn transmitter-receiver for industrial uses has a maximum torque of 2.75 oz-in. at 90 degrees, maximum ambient temperature of 170° F, and a maximum speed of 500 rpm, according to illustrated Catalog Sheet CM-14. Other details are given. 2 pages. Rotron Controls Corp., Woodstock, N. Y. D

Circle 619 on Page 19

Magnetic Amplifiers

"Magnetic Amplifier Systems for Nuclear Reactor Installations' is title of Bulletin S-963. It describes the rod programmer amplifiers designed for the Shippingport, Pa. nuclear electric power plant. Details of magnetic servo drives and applications are presented. 8 pages. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y. D

Circle 620 on Page 19

Sheathed Electric Cable

Catalog 1031 covers construction features, engineering data, applications, and other information on C-L-X sheathed cable. It is a pliable metallic duct with a built-in electric cable for power, control, signal, and communications applications. 20 pages. Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass. B

Circle 621 on Page 19

Test Point Connectors

Expressly designed for use in printed circuits, test point connectors described in Bulletin "Continental Connectors" are available with 1, 6, or 16 conveniently located test points. 6 pages. DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 622 on Page 19

Voltage Regulator

Bulletin No. 6.04 is descriptive of a new 60-finger regulator for direct control of voltage of main fields of large alternators and generators, line load regulation, power amplification, impedance matching, and system stabilization. 6 pages. Electric Regulator Corp., Pearl St., Norwalk, Conn. B

Circle 623 on Page 19

New Design Versatility with RŌTAC

Compact, powerful Rōtac Torque Actuators have a wide range of applications

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained; power can be doubled by using double-vane shafts. One moving part insures long life and low maintenance.

Rōtac Actuators can be mounted vertically, horizontally or at any angle, with the housing held stationary or with the body rotating around the shaft.

Wherever you need motion—powerful, easily controlled rotary action in compact form—Rōtac Actuators simplify design and provide unlimited possibilities for use in various applications.

FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC—How it works • Control • Typical applications and special uses • Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

MOBILE EQUIPMENT—A compact RŌTAC Torque Actuator swings this truck-mounted crane boom in a 280° travel arc; it's controlled through a 4-way valve.

MACHINE TOOLS—Automation machine for boring and grooving piston wrist pin holes uses RŌTAC Torque Actuator for positioning the orienting arbors.

FOUNDRY MACHINERY—Ex-Cell-O Model HN-66-1V RŌTAC Actuators supply the motive power for turnover of the core-box on this semi-automatic shell core blower.

PAPER MACHINERY—This collector roll is actuated by a standard model RŌTAC Actuator which unloads material after a slitting operation is performed.

EX-CELL-O CORPORATION

58-15

GREENVILLE PLANT, GREENVILLE, OHIO

XLO EX-CELL-O FOR PRECISION

EX-CELL-O PRECISION PRODUCTS INCLUDE:
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* DRILL JIG BUSHINGS
* AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS
* TORQUE ACTUATORS * DAIRY EQUIPMENT

Circle 481 on Page 19

MAGNETS
PLUS
AUTOMATION
EQUALS
MAGNAmation

New word from
ERIEZ

New efficiency
for industry

MAGNA RAILS. Lifetime powered, non electric magnetic elements that convert ordinary belt conveyors to *magnetic* conveyor elevators. Will convey ferrous items up inclines as steep as 90° — quickly, safely, with positive hold. Easily installed under existing lines, or incorporated into new equipment. Increases production. Reduces manpower needs. Saves valuable factory floor space.

VERSATILE MAGNA RAILS ARE AVAILABLE IN MANY MAGNETIC STRENGTHS IN VARIOUS BOLT-TOGETHER LENGTHS AND IN STRAIGHT AND CURVED SECTIONS, ASSURING YOU PROPER UNITS FOR SOLVING YOUR HANDLING PROBLEMS REGARDLESS OF SIZE OF PARTS.

Our men work closely with design engineers, OEMS, etc. If you need assistance, just contact us.

FREE! Big, 48-page booklet "Magnetic Ideas from Eriez". Loaded with idea-sparking illustrations, diagrams, installation photos. Send today!

FOR YOUR COPY, WRITE TO
Eriez Mfg. Co., 131-PA Magnet Dr., Erie, Pa.

ERIEZ

Circle 482 on Page 19

HELPFUL LITERATURE

Ceramic Disc Capacitors

Temperature stable, semistable, general purpose, and temperature compensating ceramic disc capacitors are subject of illustrated bulletin. Offered in 500 and 1000 wvdc ratings, these flat units have 1¼-in. or crimped leads, latter for printed circuit use. 6 pages. Electro Motive Mfg. Co., Willimantic, Conn. B

Circle 624 on Page 19

Wire Cloth

Coarse to extra-fine meshes in plain, twill, Dutch, micronic, and special weaves can be produced by this company from various metals. Available meshes and widths are described, and specifications tables are included in illustrated catalog. Micronic filter cloth can have 300,000 openings per square inch. 12 pages. Unique Wire Weaving Co., 762 Ramsey Ave., Hillside, N. J. D

Circle 625 on Page 19

Sapphires for Industry

Engineering, design, and purchasing guidance to the complete field of jewel bearings and other industrial applications of sapphire products is afforded by Manual No. 5. It is divided into sections on properties of sapphires, jewel bearings, design data, jewel bearing assemblies, and typical uses of sapphires. 34 pages. Aurele M. Gatti, Inc., 524 Tindall Ave., Trenton, N. J. E

Circle 626 on Page 19

Pipe Welding Fittings

Engineering, design, and application Bulletin FDC-268 is one of a series of 24 data folders on B & W welding fittings and forged steel flanges. It covers 16-in. nominal pipe sizes. 6 pages. Babcock & Wilcox Co., Welding Fittings Dept., Milwaukee 46, Wis. K

Circle 627 on Page 19

Hose Reels

Automatic hose reels in a variety of sizes and types for liquid and gas handling uses are described in illustrated catalog. They can be supplied for services ranging to 3000 psi for various sizes and lengths of hose. 8 pages. Gleason Reel Corp., Mayville, Wis. K

Circle 628 on Page 19

Valve Positioner

Design and performance data on the new Model J valve positioner are given in Bulletin J-1. It affords an infinite number of stroke lengths to 8 in. and operates on 30 to 150-psi air supply. 2 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. E

Circle 629 on Page 19

Magnetic Amplifiers

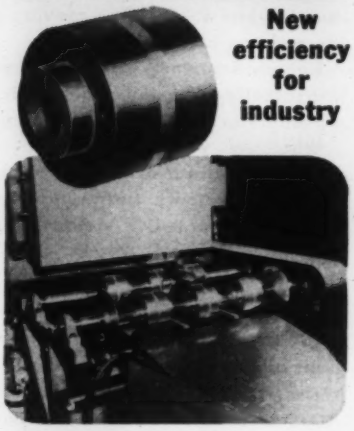
Specifications of the new 1290 Series of Super Power gapless core magnetic amplifiers are presented in Bulletin E PD 1296-5. Eighteen sizes have power outputs of 500 va to 32 kva. 4 pages. Vickers Inc., Electric Products Div., 1815 Locust St., St. Louis, Mo. I

Circle 630 on Page 19

MAGNETS
PLUS
AUTOMATION
EQUALS
MAGNAmation

New word from
ERIEZ

New efficiency for industry



MAGNA ROLLS. Permanently powered, non electric automation units for use in magnetic conveying systems. Hold, control, elevate, change direction flow of ferrous materials — from small parts to large sheets. Can be used as head pulleys or in systems not utilizing belts. For *faster, shorter, safer* conveyor lines that move at peak speeds for peak production!

MAGNETIC STRENGTH IS GUARANTEED INDEFINITELY • NON ELECTRIC; NO WIRES, ATTACHMENTS, FUSES • NO MAINTENANCE • EASILY INSTALLED ON NEW OR EXISTING EQUIPMENT • LOW INITIAL COST; NO OPERATING COSTS • VARIOUS DIAMETER WIDTHS, STRENGTHS, CONTOURS, ETC., TO MEET SPECIFIC NEEDS.

Need assistance? Contact us; we work closely with design engineers, OEMS, etc., on models and pilot set ups.

FREE! Send for big 56-page "Magnetic Ideas for Automation" booklet. Packed with idea-sparking sketches for proved-in-use installations, etc.

Eriez Mfg. Co., 131-PB Magnet Dr., Erie, Pa.

ERIEZ

Circle 483 on Page 19

THE *BEST* MACHINES MAKE THE *BEST* GEARS

Illustrated is our latest Grinder for Spur and Helical Gears up to 72" diameter . . . ultra precision work table, accurate to 4.3 arc seconds total accumulative error . . . THIS MACHINE IS THE MOST ACCURATE LARGE GEAR GRINDER IN AMERICA . . . Ultra High Precision Gears ground on this machine open new horizons of accuracy and performance of Large Gearing for Radar, Marine, Turbine, Jet Engines, Diesel Engines, High Speed Shears and many similar applications . . . Phillie Gear has 5 additional High Precision Gear Grinders.

In addition to 66 years experience and 3 large modern plants, Phillie Gear has the World's latest and finest machines for producing gears of all types and sizes, in any quantity . . . Special attention is given to selection of materials, machining, heat treatment, and tolerances — all with one thing in mind: to give you the *Highest Quality Possible.*

All gears made by us are checked and tested on the very latest machines — and then must pass the most rigorous inspection by specially trained men, before shipment — There is no "guesswork" at Phillie Gear.

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SPECTROL PRECISION MECHANISMS

Black Boxes, Dry Powder, and Missile Making

It takes a lot of black boxes plus a good bit of dry powder to launch an occasional missile down at Cape Canaveral. Some of the black boxes contain Spectrol precision mechanisms, inline or otherwise, designed to control critical flight functions.

You may be interested in one of these units that we recently delivered to the missile people which has a number of industrial control applications outside this rather esoteric field. Known as a Function Programmer, this particular 3 x 4 x 5 inch package is used for the flight control of guided missiles. Inside the Spectrol black box is a precision mechanism consisting essentially of a permanent magnet dc motor which drives a Spectrol precision potentiometer and six rotary switches of special design developed by Spectrol. These units are interconnected by an appropriate gear train. In operation, the precise opening and closing of the rotary switches and the rotation of the Spectrol precision potentiometer control the flight altitude of the missile with respect to time.

As you can well imagine, devices of this type must be built to operate within precise specifications under severe environmental conditions. In addition to the usual MIL specs, this unit was built to withstand a 2000 cps vibration at 10 G's and a shock of 50 G's. The Spectrol precision mechanism not only operates after experiencing these conditions, but during them. Overall program timing accuracy is 3 percent.

Other applications for this little Spectrol package include checking a number functions sequentially in ground support equipment, programming machine tools, and controlling the order of operation in chemical and processing plants.

To accommodate the numerous countdowns involved in missile testing, this Spectrol precision mechanism runs twice as fast in the "reset" position as the "program" position.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-assemblies is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department 572.

4

SPECTROL

ELECTRONICS CORPORATION

Sales engineering representatives in principal cities.

1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

Circle 485 on Page 19

Word Indicator Lights

Catalogs 58C and 101 describe Roto-Tellites. These word indicator lights rotate 360 degrees to facilitate re-lamping from the front. They have removable legends, positive indexing, flush mounting, and come in a range of sizes and types. 16 pages. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

Circle 631 on Page 19

Why Use Choppers?

First of a series of booklets to provide factual information on chopper techniques for design and applications engineers, booklet on the "Contact Modulator" discusses "why use choppers?" It features a glossary of chopper and amplifier terms. 24 pages. Airpax Products Co., Seminole Div., Fort Lauderdale, Fla. O

Circle 632 on Page 19

Brazing Cast Iron

The cast iron edition of Brazing News No. 80 reappraises the inherent values of cast iron by discussing its assembly to other metals through brazing. It points out that, with brazing, casting of iron components is simplified. 4 pages. Handy & Harman, 82 Fulton St., New York 38, N. Y. D

Circle 633 on Page 19

Temperature Controls

Folder 1087 introduces recording and indicating models of pneumatic temperature controls which are especially suitable for operations where steam is the heating medium. They operate in any of ten ranges from −30 to 1100° F. 4 pages. Partlow Corp., 509 Campion Rd., New Hartford, N. Y. N

Circle 634 on Page 19

Protective Coverings

Elasticones are spirally wound cones of flat ribbon steel which can be snapped over exposed shafts or screw mechanisms to protect them from dirt or injury. How these covers can be used on finished products is shown in Bulletin 57. 4 pages. Central Safety Equipment Co., 6601 Marsden St., Philadelphia 35, Pa. E

Circle 635 on Page 19

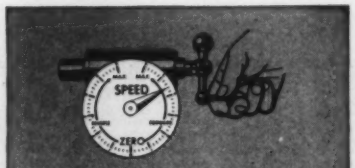
Reusable Lock Nut

Engineering data and specifications on the Conelok one-piece reusable prevailing torque lock nut are provided in folder. Fastener is adaptable to high as well as low torque assemblies. 4 pages. National Machine Products Co., Utica, Mich. H

Circle 636 on Page 19

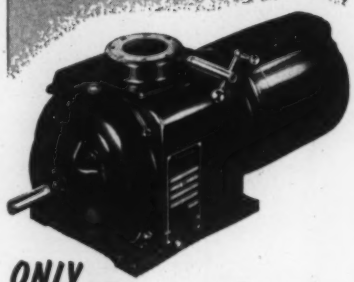
Magnetic Amplifiers

Forty-five schematic diagrams and graphs describing magnetic amplifier design and application techniques are found in Engineering Bulletin 403-A. Topics covered include signal mixing, voltage and current comparators, automatic pilot systems, electro-hydraulic valve drives, and transform generation. 16 pages. Request on company letterhead from Acromag, Inc., 22519 Telegraph Rd., Detroit 41, Mich. H



GUARANTEED GREATER ACCURACY

than any other Variable Speed Drive



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most reliable variable speed drive made

offers these...

BIG FOUR FEATURES!

1 UNLIMITED SPEED RANGE — from any desired maximum speed to zero, including reverse, without stopping motor.

2 UNMATCHED ACCURACY — of speed setting and re-setting, and of speed holding.

3 ULTIMATE in SIMPLICITY and COMPACTNESS — a straight line extension of a standard induction motor — or available without motor.

4 AUTOMATED SPEED CONTROL — control tension, proportion, synchronization, etc. from any control signal; 3 to 15 PSI, .5 to 5 ma, potentiometer, frequency, or binary signal from punch cards, tapes, or computers.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE OR WRITE FOR COPY

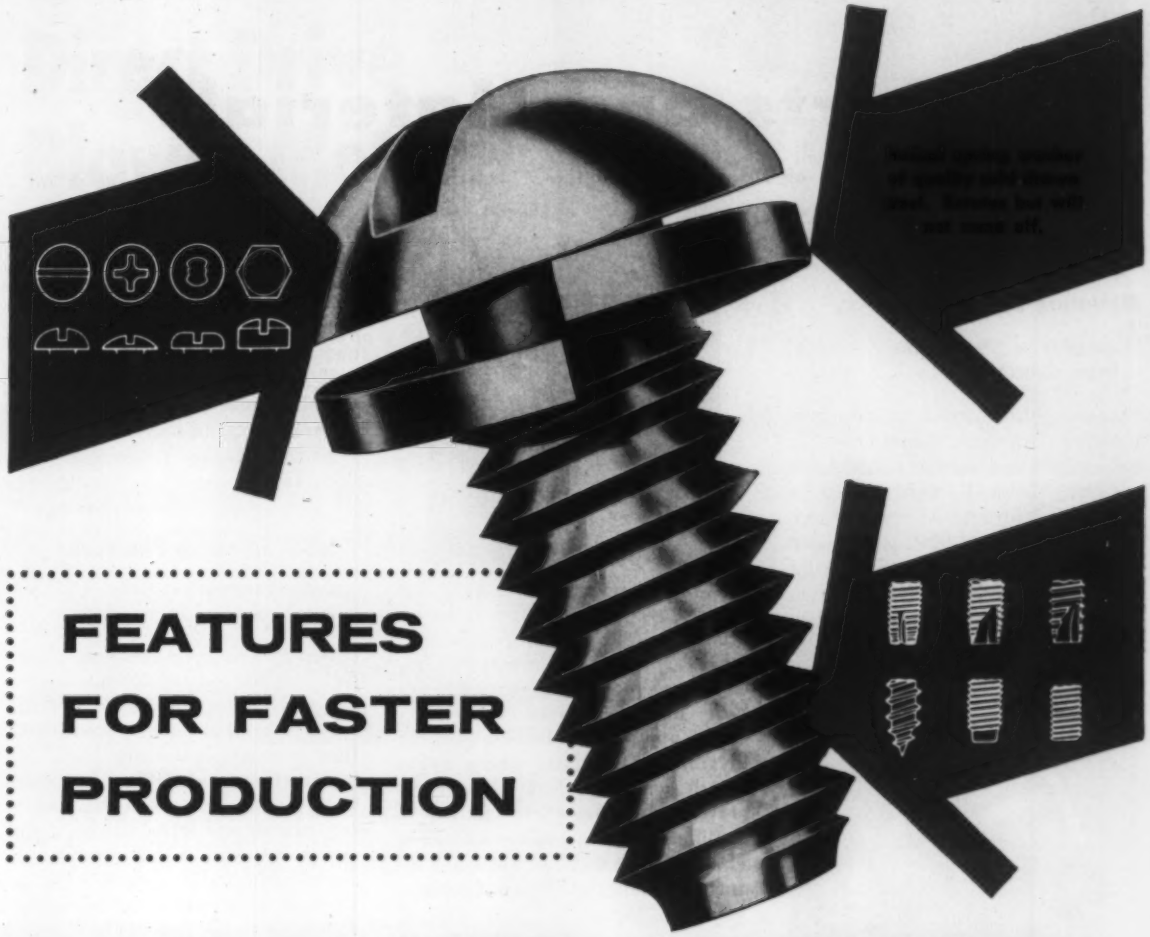
All this backed by PROVED PERFORMANCE to do a better job for LESS MONEY!

GRAHAM TRANSMISSIONS, INC.

DEPT. MD, MENOMONEE FALLS, WIS

Circle 486 on Page 19

THE BEST INDUSTRIAL FASTENER FOR THE MONEY



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Eaton-Reliance Springtites and Sems* are made to satisfy the needs of modern, high speed production in almost every field of metal fabricating. From design to final use, these fast fasteners offer features required by design and industrial engineers to make better, longer lasting products. With quality cold drawn steel as a foundation, Eaton-Reliance Springtites and Sems are headed and threaded on precision machines; the spring washer is added as a permanent part of the fastener and all work is inspected with a critical eye toward perfect performance under the most trying conditions. Products fastened with Eaton-Reliance industrial fasteners stay "factory tight" longer. Send for Engineering Bulletin S-49, or for threadcutting Springtites and Sems in Types 1-23-25, send for Engineering Bulletin S-49-A.

With multi-tooth washer

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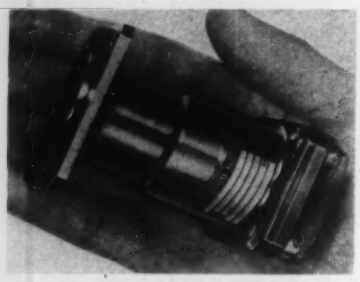
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Pump-Motor

operates at 24,000 rpm from direct drive

Hummingbird Model 013685 piston-type hydraulic pump-motor is for aircraft and missile installations requiring a small, light pump or motor in hydraulic systems. Pump delivers 2.5 gpm at 3000 psi at speed of 24,000 rpm. It has been run for 50 hr with no appreciable loss in efficiency. The all-steel unit, which weighs only 1.1 lb, features spheri-



cal piston rings, all-metal O-rings and seals, and new constant-velocity universal joint. Metallic O-rings and seals permit operation of unit with fluids having temperatures from −65 to 550 F. Used as a pump or hydraulic motor without modification, unit is equally efficient rotating in either direction. It can be run directly from high-speed turbines or similar drives, eliminating use of gear boxes. **Pesco Products Div., Borg-Warner Corp.**, 24700 N. Miles Rd., Bedford, Ohio. G

Circle 637 on Page 19

Insulated Rivets

metal fasteners have thick plastic insulation

Insulets are fasteners consisting of metal rivets with shank and underhead surfaces covered with uniformly thick plastic insulation. Nylon insulation extends slightly beyond

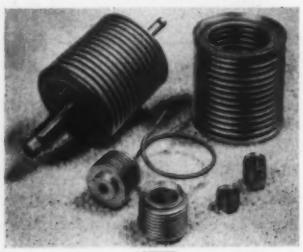
rivet-head circumference and also beyond end of rivet. Rivets are for use in electrical or electronic applications where it is necessary to fasten two or more metal parts and not have parts connected electrically. Other applications include riveting to ceramic or glass, where nylon sheath acts as a shock absorber to prevent cracking. New method of manufacture provides additional sizes and permits low prices in production quantities. **Pylon Co. Inc.**, Attleboro, Mass. B

Circle 638 on Page 19

Custom Bellows

feature accuracy of area or spring rate

Bellows for aircraft, ordnance, missiles, and other precision instrumentation are available with diameters, lengths, strokes, and spring rates to meet requirements. Hydraulically formed and cold worked, they provide maximum resiliency and service life. Single or multiple-ply construction is available, with many different heads and ends and a



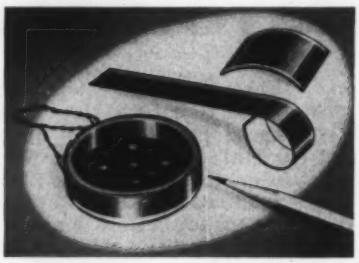
wide range of sizes. Metals include bronze, beryllium copper, stainless, and monel. Emphasis is placed on applications requiring accuracy of effective area or spring rate. **Hamilton Div., Bendix Aviation Corp.**, Fifth Street & Ford Boulevard, Hamilton, Ohio. G

Circle 639 on Page 19

Pliable Selenium Photocells

three-dimensional units can be shaped in any form

Three-dimensional selenium photocells are for use in a wide variety of electronic photoelectric devices for control applications, production-flow processes, automatic inspection and sorting, and similar functions. The pliable units can be shaped into almost any form, curved, cylindrical, or other configuration, in three-dimensional shapes with as little as 1 in. radius of curvature. Cell sizes range from ¼ x ¼ to 10



x 10 in. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 640 on Page 19

Flexible Coupling

has 15-deg angular misalignment

Tru-ax flexible coupling has two spherical-shaped hubs which engage radially mounted cylindrical shoes in each section of two-piece housing. Housing sections are bolted to-

Quietest Direct Drive Blower Motor

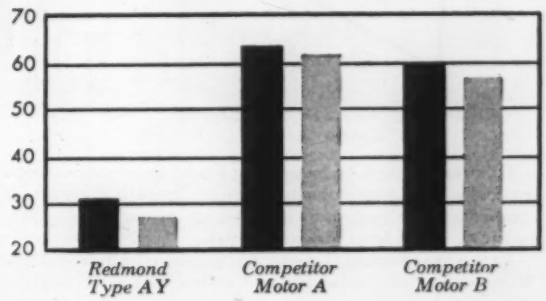
Place a mechanic's stethoscope on the end cap and you can easily hear the difference between the newly-designed Redmond Type AY and motors of conventional design. Try it on a Redmond 1/6 hp—the noise level is about that of a 1/35 hp motor of conventional design.

New Redmond Design Reduces Blower Vibration to One-Fifth that of units using Conventional Shaded-Pole Motors

Apply vibration tests and you will be quick to agree that here is the quietest direct-drive blower motor available. The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The graph shows vibration test results on the new Redmond design and two competitive motors. These tests were made with the best vibration testing equipment available. The solid black bar shows vibration on the motor end cap; the gray bar shows vibration on the blower housing. The graph is decibel readings on 120 cycles, since the 120 cycle frequency is the one that is the basic source of nearly all noise problems. Reduction of vibration is a logarithmic function—the reduction of vibration in the Redmond motor to 33 decibels reduces noise to only 1/5th that of conventional motors.

The new AY is ideal for a wide variety of applications requiring a whisper-quiet, economical, high-quality motor. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.



The Standard of Dependability

CC Redmond COMPANY, INC.

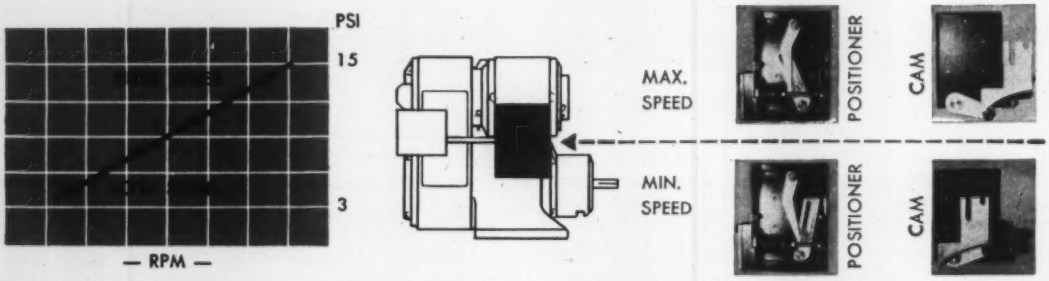
Subsidiary of CONTROLS COMPANY OF AMERICA

OWOSSO, MICHIGAN

REEVES

AUTOMATIC PROCESS CONTROL
with
Vari-Speed Motodrives

Sensitive Speed Reaction to Controller Signals ... Straight Line Variable Speed Output



• REEVES AIRtrol, in an open or closed loop system, automatically and continuously corrects operating speeds to compensate for variations in materials or energy (i.e. temperature, liquid level, density or flow).

As the final control element, the pneumatically-controlled Motodrive assures sensitive and stable control throughout the speed range.

Linear speed output is a result of the exclusive cam design. The AIRtrol responds to a 3 to 15 p.s.i. pneumatic signal, and is adaptable to all standard process instrumentation.

The AIRtrol is available on all REEVES Motodrives . . . hundreds of assemblies from ¼ through 40 hp., 2:1 through 10:1 speed range, and 1.7 through 4660 rpm.

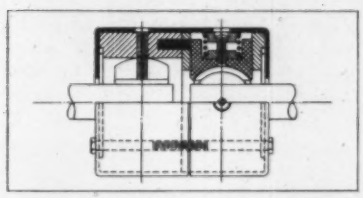
For examples of AIRtrol in process control systems, write Dept. H 39 for AIRtrol Instrumentation Data Sheets.

VARI-SPEED MOTODRIVE
VARI-SPEED MOTOR PULLEY
VARIABLE SPEED TRANSMISSION

REEVES PULLEY COMPANY
Division of RELIANCE ELECTRIC AND ENGINEERING CO.
COLUMBUS, INDIANA
In Canada: Reeves Drives • Toronto • Montreal

R MASTER REEVES

Circle 489 on Page 19



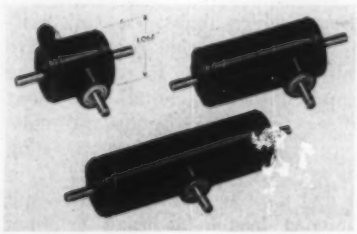
gether as a single unit. Curved lip on surface of each hub fits into curved slot on bottom of shoe, which rotates about its own axis. Design provides freedom of movement in two directions. Engagement of lip and slot is maintained under constant pressure by adjustable spring element at outer end of shoe. Operating assembly is totally enclosed by cover and nylon-disc seal assembly. Capacity is 1/40 to 3 hp at 100 rpm, and maximum speed is 1750 to 3450 rpm. Angular misalignment is 15 deg. Unit has zero end play and torsional flexibility. Coupling is for bore sizes from $\frac{1}{8}$ to $1\frac{1}{2}$ in. **Olson Industrial Products Inc.**, 40 W. Water St., Wakefield, Mass. B

Circle 641 on Page 19

Miniature Angle and T-Drives

1:1 ratio units transmit power at right angles

Series 12 angle and T-drives (top, left) can be integrally combined with a miniature speed reducer (top, right) or between two or more speed reducers (bottom) to permit take-offs with different speed reductions. The 1:1 ratio units are for applications where power must be transmitted at right angles in cramped space. Drives handle up to 24 oz-in. of torque, and speeds to 10,000 rpm are reached without excessive wear. Maximum power transmitted is 0.025 hp. Black anodized aluminum cases have size 11 servo mounts, with several other types of attachable mounts also available. Stainless-steel shafts with diam of 3/16 in. run in double heavy-duty ball



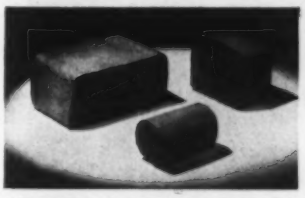
Stalwart Announces

SILICONE SPONGE RUBBER...

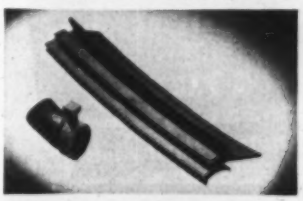
in extruded and calendered shapes

Exclusive new processes produce cross sections, lengths and densities to your specifications

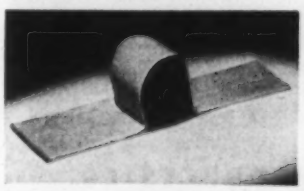
R3d2-SR



Cell sizes range from very coarse to fine with open or closed cell-structures.



Silicone sponge extrusions can be combined with solid silicone rubber extrusions.



Colendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

Here is important news for designers in the appliance, aircraft, electronics and other industries! A unique process developed by The Stalwart Rubber Company now enables silicone rubber to be extruded and sponged in complex configurations or calendered to close tolerances to meet customer specifications. Here are the facts . . . Stalwart extrudes silicone sponge parts in 1/16 to 8-inch dimensions in lengths up to 300 feet. Calendered sheets are produced in widths up to 36 inches. These silicone sponge parts resist sunlight, ozone, and aging as well as temperatures ranging from −160° to +500° F. Stalwart also mass-produces all types of precision parts from natural and synthetic rubbers.

Send today for your copy of the new Stalwart Catalog.

Another first by

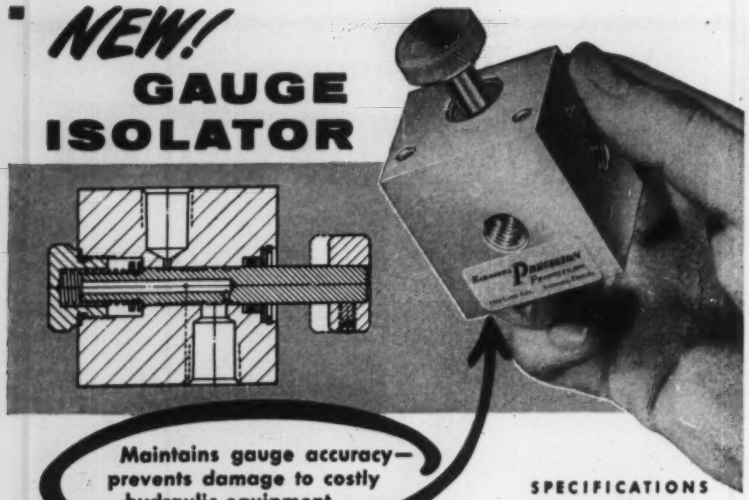
STALWART RUBBER COMPANY

180 NORTHFIELD ROAD • BEDFORD, OHIO

PLANTS in BEDFORD, OHIO and JASPER, GEORGIA.

Circle 490 on Page 19

NEW! GAUGE ISOLATOR



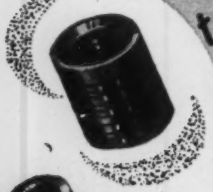
Maintains gauge accuracy—prevents damage to costly hydraulic equipment.

■ Included in any hydraulic circuit, the new SARASOTA GAUGE ISOLATOR prevents gauge damage due to surge pressure. By maintaining correct pressure with accurate gauges, damage to hydraulic components, molds, dies, etc. is prevented. The unit is normally closed, preventing flow to the gauge. Depressing the push-button opens the gauge line to permit reading. Releasing the push-button closes the gauge line and drains the gauge to the reservoir.

SPECIFICATIONS
For hydraulic oil and many other fluids.
- 5000 psi. operating pressure — 7500 psi. proof.
- ¼" N.P.T.F. ports standard.

Designers and Manufacturers of Hydraulic Valves & Devices
SARASOTA Precision products Inc.
1314 N. LIME AVENUE • SARASOTA, FLORIDA ■
Circle 491 on Page 19

L-O-N-G-E-R trouble-free service or your money back!



PROMET
ENGINEERED BRONZE BEARINGS
BUSHINGS
WEARING PARTS
Formulas Developed Specifically For Your Requirements

Will not powder in severest service nor cut or stick to the shaft because of temporary lubrication failure.
Write for literature and service data sheets, or send prints and condition of operation for recommendations and quotations.

Promet Fully Machined CORED & SOLID BRONZE BAR STOCK Saves Time, Tools & Money!

THE American Crucible PRODUCTS CO.
1321 Oberlin Avenue — Lorain, Ohio, U. S. A.

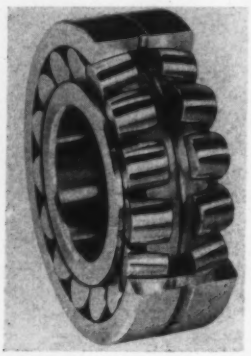
bearings. Smooth-running, 48-pitch, 20-deg pressure angle miter gears are used. Case OD is 1.062 in. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo. K

Circle 642 on Page 19

Spherical Roller Bearings

contain maximum number of largest diameter convex rollers

Series 22200 and 22300 spherical bearings are available in bore sizes from 1.5748 to 11.0236 in. with dynamic load ratings up to 288,000 lb. Bearings also will be available in pillow blocks in bore sizes from $1\frac{7}{16}$ to 10 in. Each bearing contains maximum number of largest



diameter convex rollers to provide high capacity. Centrifugally cast bronze retainers assure smooth, quiet bearing performance under extreme speeds and loads. High, heavy inner-race shoulders make it possible to assemble or remove bearings easily from shafts with conventional equipment. When furnished in pillow blocks, a choice of bearing seals is available. **Link-Belt Co.**, Dept. PR, Prudential Plaza, Chicago 1, Ill. J

Circle 643 on Page 19

Flexible Plastic Tie

for binding wiring harnesses

Flexible plastic tie of nylon-base Moldarta material has a ratchet-like design which makes the unit self-adjusting to a wide range of wire bundle diameters. It reduces time required to tie a bundle by about 30 per cent. Tie is fungus and moisture resistant, resulting in long life. Tooth form allows bending to a low limit of 1/32-in. radius, and notched leader facilitates gripping

tie for tightening. Tapered surfaces at rear of ratchet buckle and 7/8-in. long, smooth tapered surface permit ease in threading leader through buckle. Double tooth in buckle permits ratchet-holding ability almost equal to basic tensile strength of strap. Ties can be installed with or without special plier, jaws of which facilitate gripping tie for rapid tightening and clipping excess strap after installation. **Component Products Dept., Westinghouse Electric Corp.**, 4-S-18, East Pittsburgh, Pa. F

Circle 644 on Page 19

Decorative Aluminum Sheet

has glittering finish

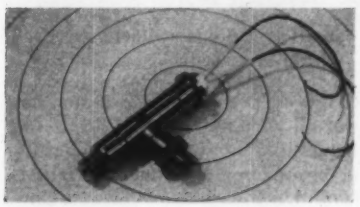
Spangle Sheet, aluminum with a glittering finish, has many applications, such as automotive trim, refrigerator and appliance trim, and lighting fixtures. Sheet is available in mill finish, spangle-etch finish, and spangle-etch finish plus decorative colors. Product is available in thicknesses from 0.032 to 0.1 in. Maximum width is 36 in., maximum length, 96 in. Other sizes and gages, and coiled sheet in mill finish, are available on special order. **Aluminum Co. of America**, 757 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 645 on Page 19

Propellant-Actuated Valve

permits no preactuation leakage

Of normally closed design, propellant-actuated valve houses a laterally moving spool and explosive cell



Cardinal Manufacturing Co., Kansas City, Kansas

An Unusual Problem...

How to dry picture tubes quickly—*from the inside*—after pouring screen. Natural drying had proved too slow—not only from an output standpoint, but also because the screening material lost its strength unless dried quickly. Narrowness of the necks of tubes posed a further problem . . . eliminated the use of conventional drying methods.

A Practical Solution...

A Spencer blower was arranged to deliver air at the required 165°F, utilizing controlled heat of compression. This heated air is carried through insulated lines to individual jets (each with multiple outlets) at rack-table arrangements. 110 tubes are processed simultaneously. Drying time of only 8 to 12 minutes is required.

BLOWER SPECIFICATIONS
TYPE: Spencer Turbo-Compressor
H.P.: 15
AIR DELIVERY: 450 C.F.M. @ 4 p.s.i.

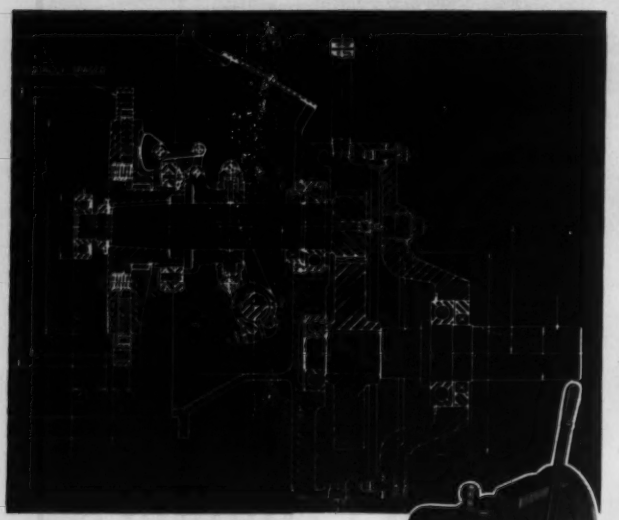
Drop a line for information on how a Spencer blower—standard or specially adapted—might help solve your product or process design problem. Spencer blowers are available in standard capacities for 1/3 to 1,000 H.P., volumes up to 20,000 C.F.M. pressures 4 oz. to 10 lbs.

Request Catalog 126A containing complete specifications on Spencer Blowers.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 493 on Page 19

ROCKFORD



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

SPEED REDUCERS
(Reduction Gears) With
OVER-CENTER
Gear-Tooth Drive
CLUTCH

ROCKFORD Speed Reducers incorporate a complete clutch power take-off and reduction gear assembled into one complete unit. They are suitable for the transmission of power from internal combustion engines where out-put shaft speeds required are lower than engine speeds. A heavy-duty, over-center clutch, with gear-tooth drive construction is used. Positive engagement or disengagement position is accomplished by mechanical action of toggle arrangement. Various reduction ratios are available. Standard S.A.E. housing sizes.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

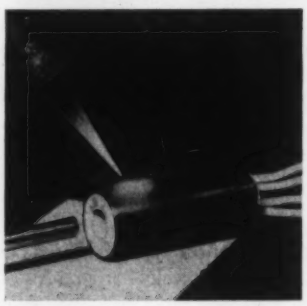
which drives it. Inlet fitting has a blind end to eliminate possibility of preactuation leakage. When valve is assembled, end of fitting recesses into a counterbore in spool. Actuation results in shearing off blind end to permit fluid flow past recess in spool and to outlet port. Metal particles are trapped in counterbore, and O-ring seals trap expended combustion gases so they neither escape from valve nor contaminate working fluid. Design permits use of a reload kit for reusability in either systems test and check-out activities or where valve is used for emergency purposes and must be restored after use. **Beckman & Whitley Inc.**, 985 E. San Carlos Ave., San Carlos, Calif. M

Circle 646 on Page 19

Differential Transformers

withstand 2000-F temperatures for short periods of time

Type 6208 HHK and 6206 HHK differential transformers are wound on ceramic bobbins, with leads terminated on lugs for secure connections. Units withstand 2000 F for



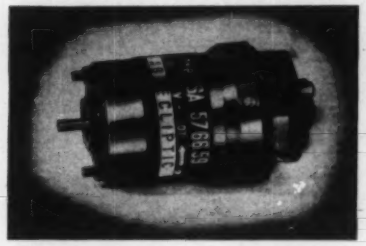
periods up to 5 min. The 6208 HHK is for linear-displacement measurements up to ±0.16 in. and Type 6206 HHK for displacements to 0.5 in. Units are available for prototype and model evaluation. **Automatic Timing & Controls Inc.**, King of Prussia, Pa. E

Circle 647 on Page 19

DC Governor Motor

small unit holds uniform speed within 1 per cent

M-120 constant-speed dc motor has over-all dimensions of 1½ x 3 in., including shaft which protrudes ½ in. beyond motor frame. Weight is 7 oz. Unit is equipped with a gov-



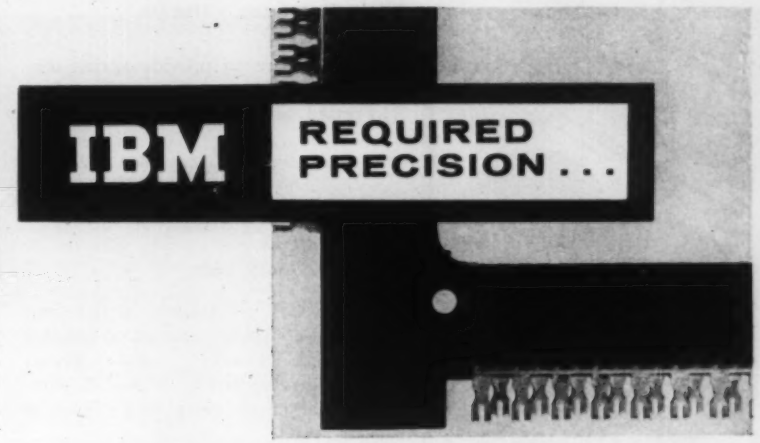
ernor that controls shaft-speed variation within 1 per cent. Motor is rated up to 1/100 hp at 4500 to 9000 rpm, with a rotor torque of 3.5 oz-in. for intermittent duty. Rotation can be supplied clockwise or counterclockwise. Wide range of outputs is available, with input voltage from 24 to 48 v dc. Shaft diameters are from 0.109 to 0.118 in. Stud mountings are available for 4-40 thread. Body of motor is solid aluminum with anodized finishes available in six colors. **Carter Motor Co.**, 2719 A, W. George St., Chicago 18, Ill. I

Circle 648 on Page 19

Lightweight Lock Nut

for temperatures to 1200 F

No. FN1216 high-strength lock nut has minimum tensile strength of 200,000 psi at room temperature and over 150,000 psi at 1200 F. Available in four diameter sizes from No. 10-32 through $\frac{3}{8}$-24, reusable nut is intended for structural applications in jet engines, missiles, aircraft, and related equipment. It is up to 57 per cent lighter than conventional 1200-deg standard unit. Unit can be mounted closer to corners and perpendicular bulkheads, and generally permits smaller bolt circles in flange applications, affording additional structural weight savings. Tests indicate excellent locking retention and high stress-rupture life. Annular threaded collar at top of nut is closed in at three points during

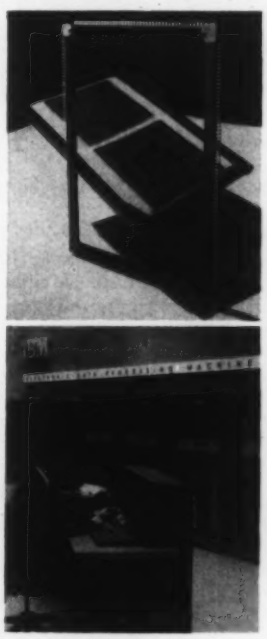


and got it from CONSOLIDATED

This 12" x 15" phenolic "Memory Frame" for IBM was plunger molded in one piece with 440 wire terminal inserts. Later, strung with copper wire containing a series of 8,000 ferrite magnetic cores, these frames are stacked one atop the other and wired together in conjunction with other components to give IBM's 705 Data Processing System a "memory" capacity of 40,000 characters.

Dimensionally stable frames that would withstand dip soldering at extra high temperatures were a necessity. They could not bow or crack, nor could there be more than minimum after-shrinkage or expansion once assembly was completed.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.



Send for your free copy of our new 20-page Facilities Report.

CMP

"Your Blueprint in Plastics" Since 1874

CONSOLIDATED MOLDED PRODUCTS CORPORATION

335 Cherry St., Scranton 2, Penna.

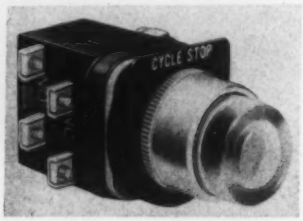
manufacture to provide spring-tension locking action. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 649 on Page 19

Pushbutton-Pilot Light

is oiltight, heavy-duty unit

No. 800T illuminated pushbutton unit is completely sealed to exclude oil and coolants. Contact blocks have double-break, NO—NC contacts of silver alloy which require



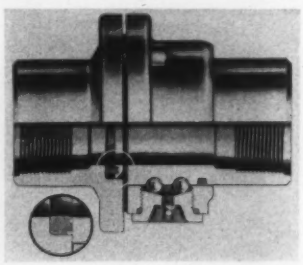
no maintenance. Flexible circuitry permits pilot lamp to be wired to go on or off when button is pressed, or it can be energized from a separate source. Unit can also be wired as a push-to-test pilot light, and normal pilot-light lenses are available for this service. The heavy-duty control unit is equipped with a step-down transformer to supply 6-v pilot lamps. Unit is designed to fit standard oiltight enclosures. Button-type lenses are available in a variety of colors, and guard collars are furnished to protect button. Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis. K

Circle 650 on Page 19

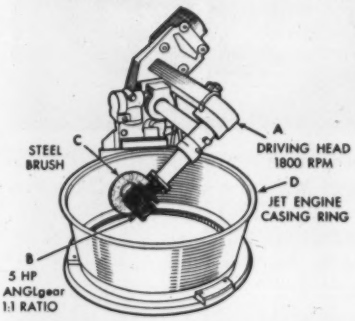
Swivel Joint

has interchangeable packing

Ball-bearing swivel joint, designated DS, is available in sizes from 3/8 through 4 in. in six of eight basic swivel-joint configurations. Unit features interchangeability of pack-



ANGLgear® simplifies power-brush drive

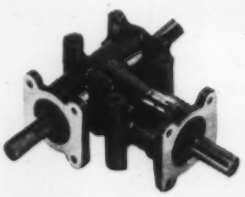


Drawing shows ANGLgear application on Osborn Brushamatic® unit developed for finishing jet engine case components. ANGLgear permits compact design, has capacity to withstand reversal every 20 sec. without overheating.

Osborn Manufacturing Co., a Cleveland, Ohio, producer of power-brush finishing machinery, has found ANGLgear ideal for adapting brushing heads to right-angle drive. Offering high capacity for its size, ANGLgear permits compact head design, facilitates brushing in restricted spaces. At the same time, its light weight cuts the overhung load to a minimum, helping reduce bearing wear. And it has the stamina to meet operating conditions that include reversal every 20 seconds —without overheating or undue wear.

Perhaps ANGLgear can solve a similar 90° drive problem for you. Completely enclosed, permanently lubricated, and featuring universal mounting, it is easily incorporated in your power transmission systems and requires little or no maintenance.

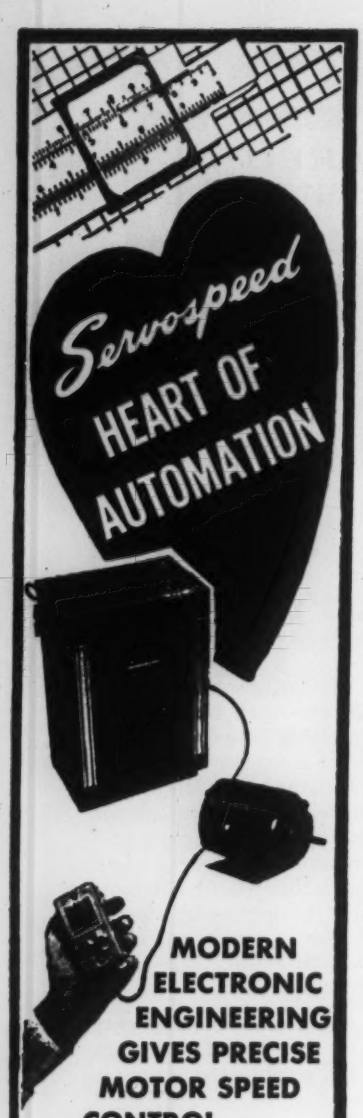
You can specify standard ANGLgear in 1/3, 1, 2 1/4 and 5 hp ratings, with 1:1 or 2:1 gearing and 2 or 3-way shafting. See data in Sweet's Product Design File or contact our local distributor.



AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 496 on Page 19



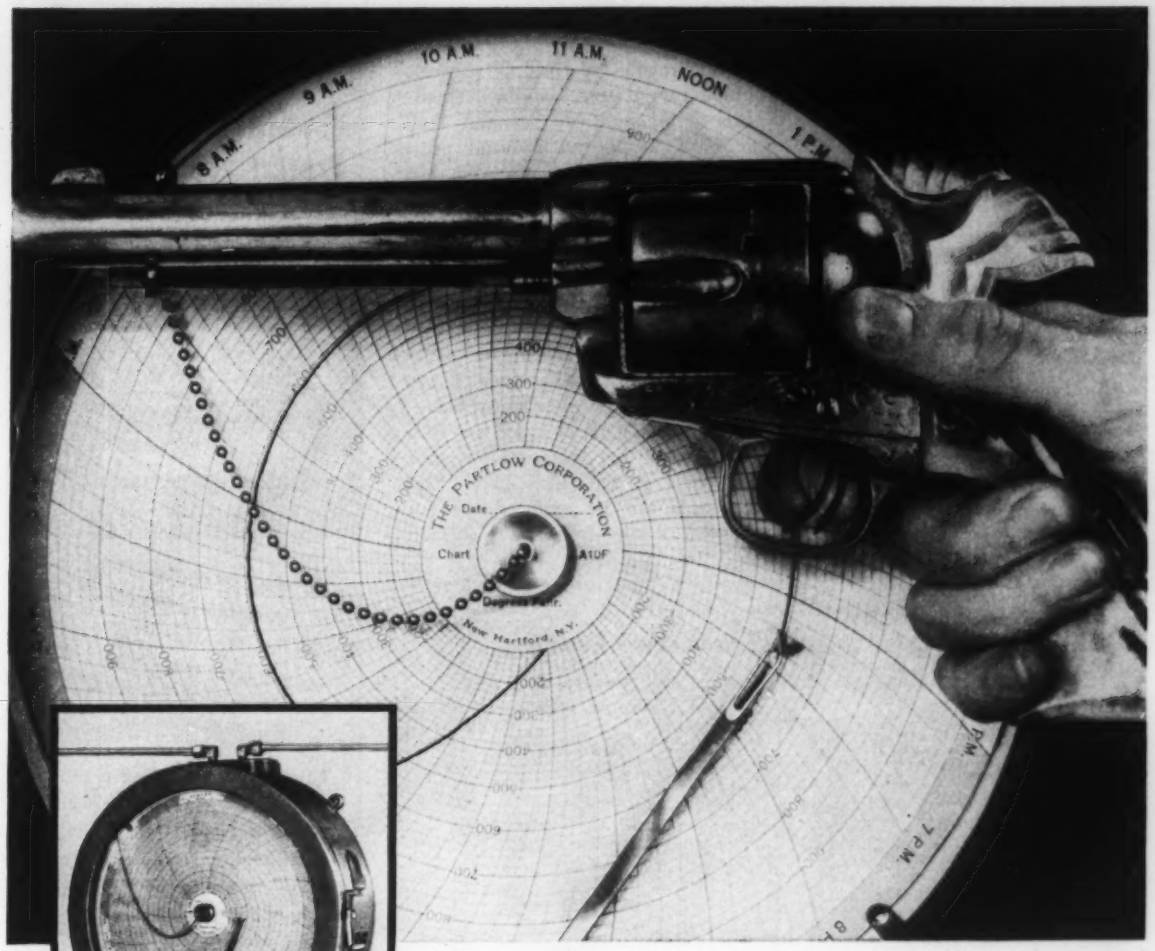
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

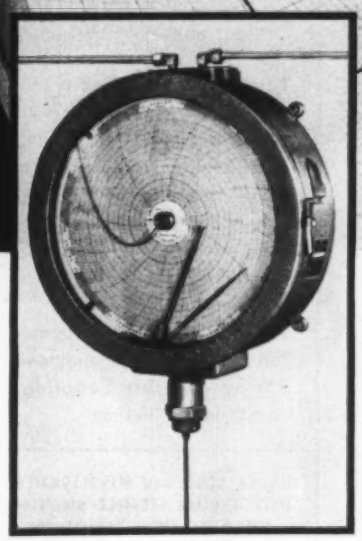
1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 495 on Page 19





The Control Geared for

HAIR TRIGGER RESPONSE

even to Fractional Changes in Temperature!

NEW *Recording Pneumatic Temperature Control, Model RVA, available in any of 10 ranges from -30° to 1100° F.*

Extreme sensitivity—reflected in lightning-fast reaction to temperature changes—is a characteristic of *all* Partlow controls. Partlow Recording controls, however, *prove it in writing* . . . You can see for yourself how exceptional bulb sensitivity, teamed with advanced mechanical design, provide a minimum of "saw-toothing" on start-up, and maintain a rigid line of control when temperature reaches a predetermined set point.

Instant response, of course, is just one of Partlow's many built-in advantages. Another is rugged *design simplicity* that does away with hair springs and delicate electronic gadgets . . . that requires no electronic amplification . . . that permits fast, "screwdriver" replacement of the thermal element *right out in the field.*

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow Pneumatic, electric or self contained gas control to fit your application *precisely*. Recording, indicating and non-indicating models available. For full details write The Partlow Corp., New Hartford, New York, Dept. D-259.

Export Reps: Ad. Auriema, Inc., 89 Broad St., New York 4, N. Y.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

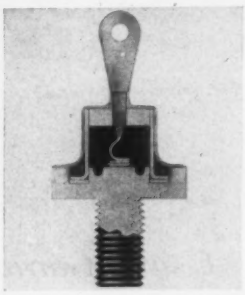
Circle 497 on Page 19

ing to provide for multiple services. These range from handling chemicals at temperatures between −40 to 400 F at 300-psi internal pressure, to handling steam and hot gas, providing for steam service rotation with recommended maximum of 440 F at 360 psi. Maximum temperature rating is 600 F at 200 psi for occasional swing or oscillating services. Cold working pressure is 1000 psi. Molded elastomer packings (inset), including Viton A, are available for use with many chemicals and for general liquid services. For steam, hot gas, and certain chemicals, a disc seal is used. Packing seals can be replaced without removal of joint from line. **Chiksan Co., Brea, Calif.** L

Circle 651 on Page 19

Silicon Power Rectifiers

have low forward drop and high insulation resistance



New silicon power rectifiers feature diffused silicon junction, solid copper base, hot tin-dipped terminal, hermetic seal for silicon chamber, and tough epoxy protective coating. They have excellent reliability and uniformity, low forward drop, and superior reverse characteristics at all temperatures. Rectifiers also provide high insulation resistance and current ratings. **Electric Products Div., Vickers Inc.,** 1815 Locust St., St. Louis 3, Mo. I

Circle 652 on Page 19

Transparent Plastic

is now available in rod form

Homalite 100 plastic withstands temperatures to 230 F and can be subjected to substantially higher temperatures for short periods. It is now available in rods of ¼ to 2-in. diam with lengths to 36 in. Mate-

TUBULAR RIVET COST-SAVINGS MULTIPLY WITH MILFORD'S ASSEMBLY ANALYSIS

1. WE STUDY THE FUNCTION

2. WE DESIGN THE RIGHT PART

3. WE RECOMMEND THE BEST ASSEMBLY TECHNIQUE

Smart designers are getting an assist from Milford—not only with basic design tips—but with a complete Assembly Analysis from drawing board to finished product.

For the answers to assembly problems . . .

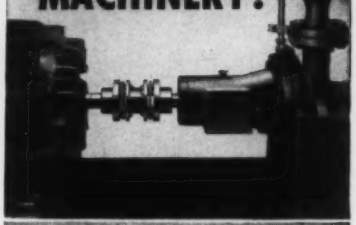
. . . get in touch with Milford first!

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

Circle 498 on Page 19

THOMAS FLEXIBLE COUPLINGS Protect your PUMPS and other Indispensable MACHINERY!



NO LUBRICATION
NO MAINTENANCE
NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.

They will protect your equipment and extend the life of your machines.

Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES:

- Freedom from Backlash
- Torsional Rigidity
- Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection While in Operation
- Original Balance for Life
- No Lubrication
- No Wearing Parts
- No Maintenance

Write for Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 499 on Page 19

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

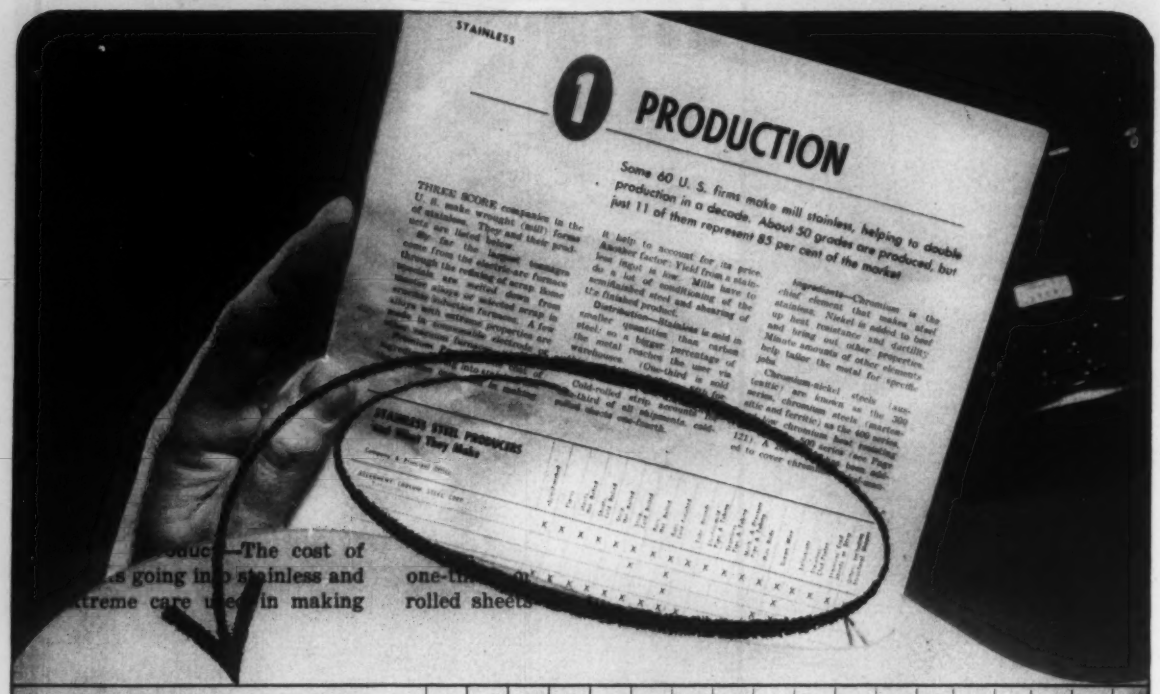
8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels


STAINLESS
1 PRODUCTION
Some 60 U. S. firms make mill stainless, helping to double production in a decade. About 50 grades are produced, but just 11 of them represent 85 per cent of the market
STAINLESS STEEL PRODUCERS and What They Make

STAINLESS STEEL PRODUCERS and What They Make Company & Principal Office	Semifinished	Plates	Sheets, Hot Rolled	Sheets, Cold Rolled	Strip, Hot Rolled	Strip, Cold Rolled	Bars, Hot Rolled	Bars, Cold Finished	Tube Rounds	Electricweld Pipe & Tubing	Seamless Pipe & Tubing	Mech. & Pressure Pipe & Tubing	Wire Rods	Drawn Wire	Extrusions	Stainless Clad Plates	Stainless Clad Sheets or Strip	Other, Including Structural Shapes
ALLEGHENY LUDLUM STEEL CORP. Pittsburgh	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
[illegible]						X		X						X				

Of the 60 producers of stainless steel...

only ALLEGHENY LUDLUM makes all sizes, shapes, finishes and analyses

In its November 4, 1957 issue, STEEL magazine published a complete run-down on the stainless steel industry. This article reveals that *only Allegheny Ludlum*, of the 60 some companies making stainless, produces all sizes, shapes, finishes and analyses.

This can save you considerable time and money. When you make Allegheny Ludlum your *one* source of stainless, you work with *one* sales engineer—*one* order, whether you buy sheet, strip, bars, tubing or whatever.

And, at the same time, you get the best technical service. A-L's crack research and development department is continually searching for new alloys, and better ways to use today's. Its findings are freely available to you through sales engineers, technicians and special literature.

Allegheny Ludlum follows the product from the melt through to finished form, has greater quality control over the stainless you buy. And since A-L makes all forms of stainless, you get unbiased recommendations as to what is best for your individual needs.

Profit by Allegheny Ludlum's status as the only one-source integrated supplier of all stainless forms. Call your A-L representative today . . . see how he can save you money and time. Or write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

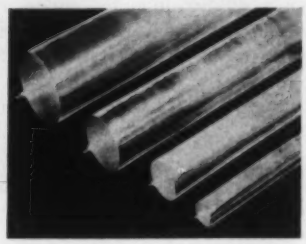
WSW 7121

ALLEGHENY LUDLUM

for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT



rial resists abrasion and is unaffected by any known solvent. Rods can be sawed, drilled, or machined without difficulty. Plastic does not crack, craze, or discolor on exposure to sunlight and the elements. It has a persistent memory for its original shape, high impact strength, and is not brittle even at low temperatures. **Homalite Corp.**, 15 Brookside Dr., Wilmington 4, Del. C

Circle 653 on Page 19

One-Part Epoxy Adhesive

for high-speed production use

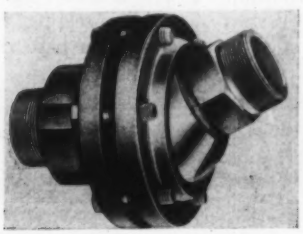
Isobond 331 is a one-part, 100 per cent epoxy adhesive which cures at moderate temperatures. Designed primarily for high-speed production use, material has great adhesion to metals, glass, ceramic, and most plastics. Shear strength to aluminum is 3000 psi. Material resists most acids, alkalies, and solvents, and can be used safely at operating temperatures from −70 to 175 C. Thermal shock does not produce cracking. **Isochem Resins Corp.**, 221 Oak St., Providence 9, R. I. B

Circle 654 on Page 19

Adjustable Joints

for use with large-capacity nozzles

Three large-size adjustable joints are for use in spray-nozzle installations where variable angular adjustment of nozzle is desired. Joints are for nozzles with 1½, 2, and 2½-in. NPT connections. Ball-joint design permits positioning at any point



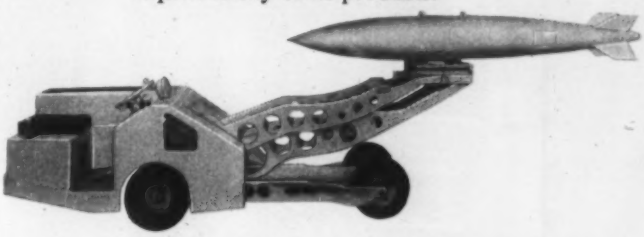
a NICAD TRADEMARK battery

...PACKAGED PAYLOAD of RELIABLE POWER at -40°

for Standard Manufacturing's MJ-1

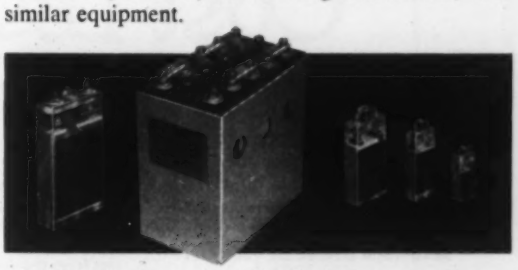
Capable of completely dependable operation at −40°F.

an exceptionally rigorous performance demand met by Standard's MJ-1 and its components—of which the NICAD nickel cadmium battery is a vital one. Standard uses a 6 volt NICAD sintered plate battery as the engine starting power source on these bomb lifts . . . and avoids engine starting failure which would detract from the service and dependability of its products.



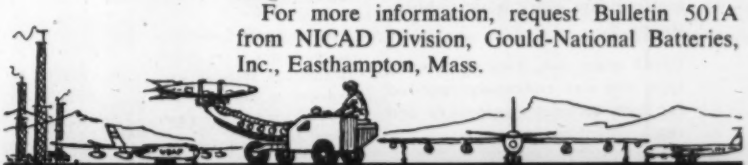
NICAD batteries will not freeze in any state of charge, and perform at peak efficiency in temperatures below the −40° requirement here, and as high as 140°.

Also produced in smaller sizes that make sense to designers, NICAD sintered plate batteries possess power output and other advantages that make them especially adaptable to the confined systems of missiles, aircraft, telemetering instruments, and similar equipment.



NICAD offers cycle life which far exceeds that of any other type battery . . . peak operational efficiency under severe conditions . . . low internal resistance that creates high discharge rates . . . capacity range from ½ to over 150 ampere hours.

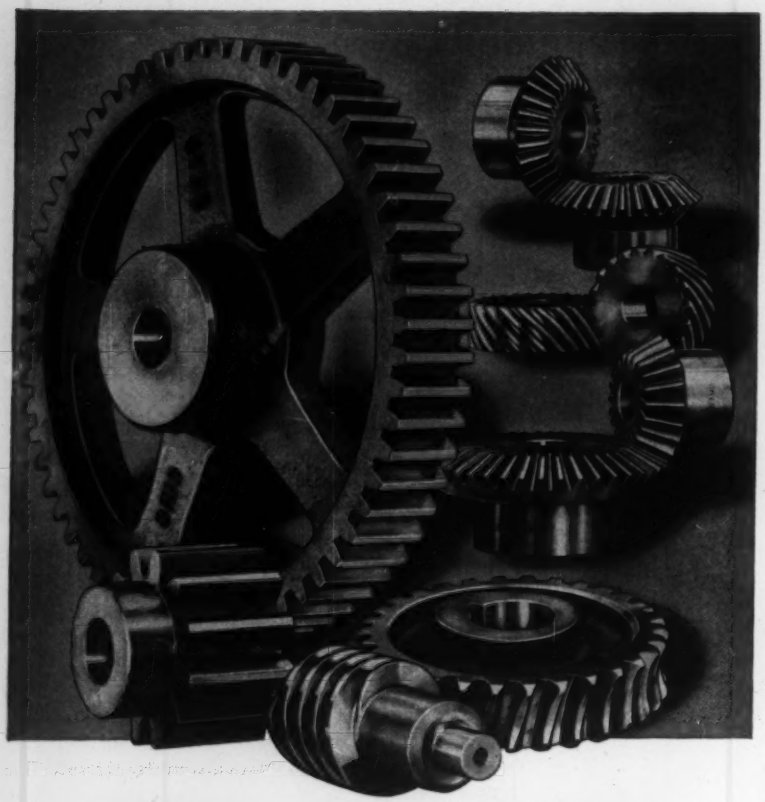
For more information, request Bulletin 501A from NICAD Division, Gould-National Batteries, Inc., Easthampton, Mass.



NICAD TRADE MARK

NICKEL CADMIUM ALKALINE STORAGE BATTERIES

Circle 502 on Page 19



OHIO STOCK GEARS

Cost Less

Compare Prices and See

■ Today, OHIO stock gears cost considerably less than other stock gears of comparable quality. Yet, in spite of this important savings you need not sacrifice a single advantage offered by your present supplier.

Make your own comparison of these points:

OHIO gears provide top quality that matches every basic industry standard.

OHIO gears are stocked in every type and size commonly required for both original equipment and replacement purposes.

OHIO gears are available for fast delivery from local stocks in 52 major cities throughout the United States and Canada.

Finally, OHIO gears are easy to order from the new 190 page catalog.

On every count, OHIO gears offer top value at lower cost. Ask the OHIO distributor in your area to quote on your requirements and make your own comparison.

Get This Handy Catalog — Spiral bound to lay flat, it is carefully planned and indexed to put complete information at your finger tips.

Manufacturers of gears and speed reducers - both stock and special

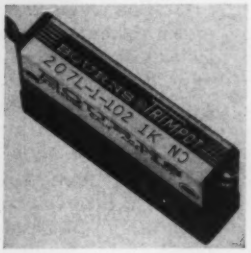
hio OHIO GEAR Company 1338 East 179th St. • Cleveland 10, Ohio

over a 40-deg included angle and 360-deg rotational range. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill. I

Circle 655 on Page 19

Miniature Potentiometer

has fused element-to-terminal bond



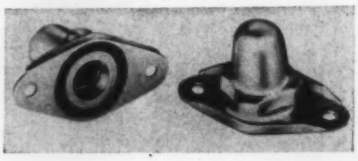
Improved Model 207 Hi-R Trimpot adjustment potentiometer is only 9/32 x 13/16 x 1¼ in. in size, permitting stacking of seven units in less than 2 sq in. of panel space. Fused element-to-terminal bond, called Silverweld, is virtually indestructible under thermal or mechanical stress. Unit has 100 K resistance, maximum operating temperature of 175 C, and power rating of 2 w at 50 C. The 25-turn, self-locking shaft insures stable settings under extreme conditions of shock, acceleration, and vibration. Element is made with a low-temperature-coefficient resistance wire and a ceramic card to provide stability at high temperatures. **Bourns Laboratories Inc.**, P. O. Box 2112, Riverside, Calif. L

Circle 656 on Page 19

Self-Locking Cap Nuts

for aircraft and missile applications

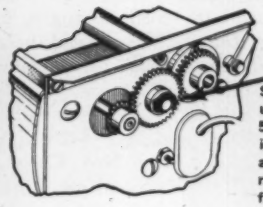
Type A2502 self-sealing, self-locking capped anchor nut seals against leakage past fastening joints in integral wing tanks, pressurized cabins, and missile fuel cells. Assembly consists of a heat-treated, drawn-steel shell, a rubber sealing ring molded to an aluminum base ring,



Circle 503 on Page 19

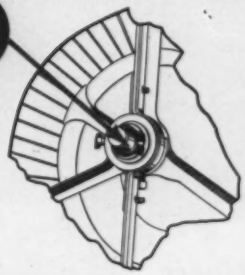
Truarc Rings Eliminate Parts and Machining, Speed Assembly, Reduce Manufacturing Costs

Ring eliminates nut and threading, saves $365/M



Sanborn Co., Waltham, Mass., uses a Waldes Truarc Series 5555 Grip ring* to secure the idler gear assembly of its portable electrocardiograph. The ring assures faultless gear performance necessary for diagnostic accuracy, eliminates a nut and threading operation for savings of $365 per 1000 units.

Ring saves parts, speeds assembly for savings of $260/M



Fraser and Johnston Co., San Francisco, Calif., uses a Series 5555 Grip ring* to secure the fan shaft and speed assembly of its furnace blowers. The ring eliminates a collar and set screw for savings of $180/M on materials, $80/M on assembly time—a total of $260 per 1000 units.

2 standard rings replace 4 special parts, save $170/M

Sanymetal Products Co., Inc., Cleveland, O., uses a Series 5005 Self-locking ring and a Series 5103 Crescent® ring* to hold the escutcheon plate and handle of this doorlatch for toilet compartments. The two standard rings replace four expensive chrome-plated brass parts for savings of $170 per 1000 units.

Ring replaces spring and washer; speeds assembly 50%, saves $15/M

Allen-Bradley Co., Milwaukee, Wisc., uses a Series 5139 Prong-Lock ring* to secure the adjustment knob of its pneumatic timer. Ring eliminates a costly coil spring and washer, simplifies a tough assembly operation. Cost saving: $15 per 1000 units. Assembly time saving: 50%.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get:

Statistically Controlled Quality from raw materials to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Field Engineering Service: More than 30 engineering minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today . . let our Truarc engineers help you solve design, assembly and production problems . . . without obligation. e.2

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N.Y.

Consult the Yellow Pages of your Telephone Directory for name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Waldes Kohinoor, Inc., Long Island City 1, N. Y.

Please send me your new 24-page Catalog No. RR 10-58 with descriptions and illustrations of the complete line of Truarc retaining rings, pliers and accessory tools and 80 typical applications.

(please print)

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

MD-29

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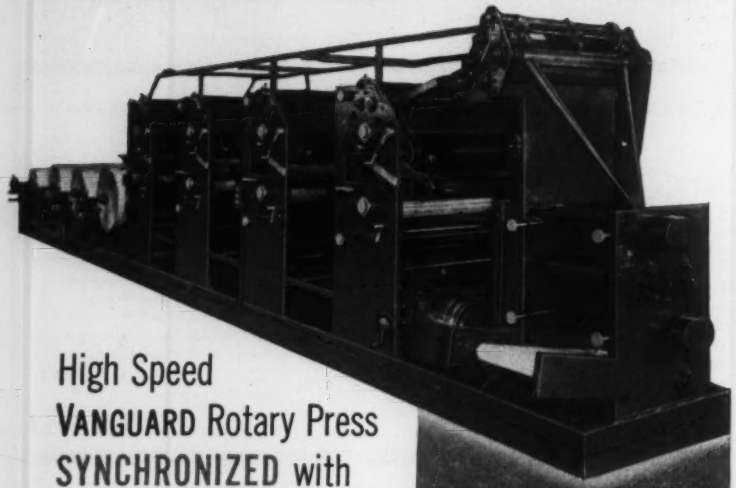
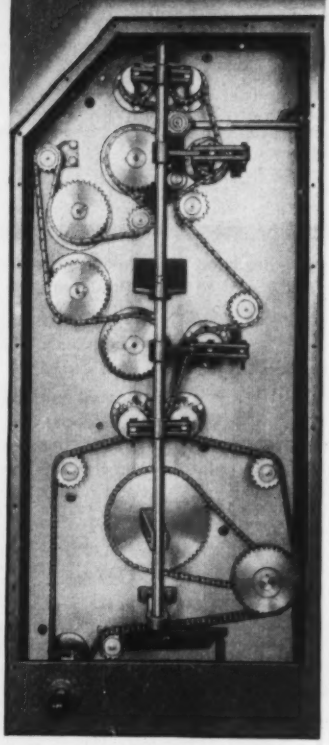
*Covered by one or more of the following patents: Nos. 2,382,948; 2,491,306; 2,574,034; 2,758,698.

You can solve many problems better and at lower cost with DIAMOND Roller Chain



High Speed
VANGUARD Rotary Press
SYNCHRONIZED with

DIAMOND roller chain



Only DIAMOND Roller Chain is used to synchronize the multiple rollers of the new Vanguard high speed newspaper press, designed and built by Ghormley Engineering & Manufacturing Corp., Fort Worth.

Ghormley engineers selected DIAMOND because its uniform pitch and dimensional accuracy make it possible to maintain perfect register and uniform paper tension at high speeds. The press produces up to 12,500 completed newspapers per hour.

DIAMOND Roller Chain offers many opportunities to improve and simplify machine design . . . to solve difficult power transmission problems.

Write for catalog containing complete information on DIAMOND Roller Chains and Sprockets. Engineering assistance is available.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
Dept. 435 • 402 Kentucky Ave., Indianapolis 7, Ind.
Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

Circle 505 on Page 19

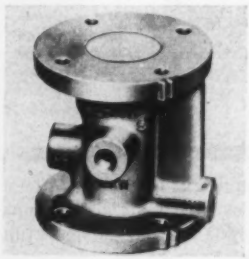
and a self-locking nut which is free to float 0.020 in. laterally from centered position inside cap to compensate for possible bolt misalignment during assembly. Dimensioned for close-clearance applications, low-height, rounded dome allows sufficient clearance within cap for both short and long-thread-length bolts. Nuts exceed minimum requirements of MIL-N-25027 (ASG) for twist-out, push-out, tensile strength, and locking torque. Nut thread height is adaptable to shear thread length bolts at rated tensile loads of 125,000 to 140,000 psi. Nuts are available in No. 10-32 and No. 1/4-28 thread sizes. **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J. D

Circle 657 on Page 19

Air Valve Adaptor

pilot section makes available accurate time delays to 1 min

P adaptor is a pilot section designed to work in combination with Graymodel TD head and any Skyline body. Adaptor provides time delays to 1 min. It uses an alter-



nate internal or external pilot supply. Individual pressure can go directly to each of three working components or pressure can be supplied in any combination of hookups. **Ross Operating Valve Co.**, 120 E. Golden Gate, Detroit 3, Mich. H

Circle 658 on Page 19

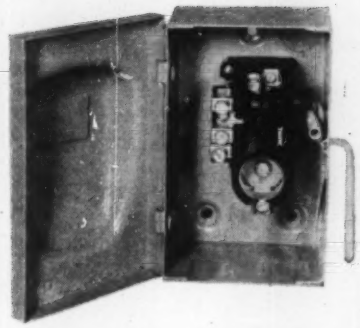
Numerical Indicator Tube

has life of more than 10,000 hr

Nixie indicator tube, Type B-5031, is an all-electronic indicator which presents ten numerals, 0 through 9, in a common in-line viewing area. Unit has life of more than 10,000 hr, and is similar in mechanical and

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **New safety switch idea**
- **Phenolics in data processing**
- **What's hot in heat resistance**



A switch for fumblers

Ever try to change a fuse on a 30-amp switch in pitch darkness?

"No—and why should we?" retort the designers of many such useful devices. "Anyone who doesn't have a flashlight handy for these little emergencies is asking for trouble."

"Yes—and it was a horrible experience," breathes the designer of *this* switch. "Young son had used up all the flashlight batteries at Scout camp. Horrible. Gave me the idea for a switch *anybody* could re-fuse. It works, too."

This insight into the limitations of the average American householder is now helping to swell demand for the 30-amp safety switch pictured here. As you can see, the crossbar that actuates the contact has been moved to the back where it cannot get in the way of fumbling fingers.

To accommodate the new design, a one-piece block of Durez phenolic supplants a two-piece porcelain block. The more compact block of Durez allows extra hand-room for wiring the switch, and weighs less without loss of performance.

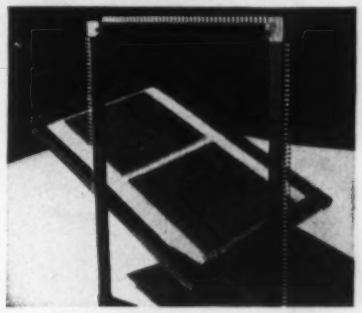
Have you an idea for a better electrical device? The odds are good that one of more than 200 Durez molding compounds can give it the exact mix of properties you want it to have. To narrow the uncertainty, see your molder or write us direct.

Jet-age abacus

With the help of Durez plastics, man can string words and numbers on wire like beads and pick them off again in millionths of a second.

His modern abacus is the IBM magnetic core memory. Thousands of tiny ferrite cores are wired into a frame like the one in the middle of this page. In an array of these core planes, stacked one atop another, electrical impulses alter the magnetic state of cores. A line of cores, some altered, some neutral, stands for a word or number, awaiting the impulse that releases it for calculation.

IBM engineers needed modern materials to bring this jet-age concept into being. The frame that supports the cores must be an excellent insulator. It must be free of internal stress that would cause warping or cracking. During assembly it must withstand the heat of dip soldering without losing its dimensions. Once assembled, it must not shrink or expand.



International Business Machines Corporation

For the core frame, designers and molder chose a mineral-filled Durez phenolic that delivers the ultimate in stability, heat resistance, dielectric strength, and moldability, meeting all requirements.

Other Durez phenolics prove their inborn versatility in the molded circuits of stepping switches, emitters, and zebra plates in new IBM accounting machines.

How much for a handle?

No, you don't really need a slide rule to design a coffeepot handle, but it helps.

This designer, at the moment, is not concerned at all with the compound-curve esthetics of coffeepot handles. He is simply figuring out how many handles his molder can make out of 1,000 pounds of which molding compound, and for how little money.

With the slide rule, it takes him only three and a half minutes to learn that his best bet for *this* handle is likely to be *Durez 1308*. Of the many mineral-filled phenolics we make, this one is in the lower gravity range. More pieces per dollar.

He has already checked into *1308's* other traits: rich black surface, uniform luster, good heat resistance (it withstands 450°F for short periods), low water absorption, flexural and tensile strengths OK.

His molder confirms the choice, for different reasons: he can get *1308* in four different plasticities, can plunger mold it, and it cures fast. Looks as if another good product is off the ground.

You don't design handles? Well, *1308* appears to fit into more heat-resistant applications than any comparable material ever developed: appliance and meter housings, wiring devices, tube bases, sockets, coil forms. The list goes on and on. But we'll stop so you can talk to your molder about *1308* for that next hot-spot job.

For more information on Durez materials, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of Durez thermosetting compounds, Hetron fire-retardant polyester resins, and Durez phenolic bonding resins.
- ☐ **"Durez Plastics News,"** mailed periodically, shows and describes latest uses of Durez materials.

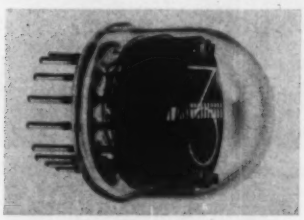
Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

U E HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
502 Walck Road, North Tonawanda, N. Y.

Circle 506 on Page 19

ALIVE TODAY!
Arch Lightbody is one
of 800,000 Americans cured of cancer
because they went to their doctors in time.
They learned that many cancers
are curable if detected early
and treated promptly.
That's why an annual health checkup
is your best cancer insurance.
AMERICAN
CANCER
SOCIETY



electrical characteristics to standard Type 6844-A. Only change required to make the tubes interchangeable is a reduction in value of series anode resistance under rated operating conditions. Tube has wide-angle readability, low power, and brightness of presentation under all ambient light conditions. **Electronic Tube Div., Burroughs Corp.**, P.O. Box 1126, Plainfield, N. J. D

Circle 659 on Page 19

Miniature Nylon Screws

in No. 2-56 and 3-48 sizes

Miniature molded nylon machine screws have many applications in the electronics field. Available in No. 2-56 and 3-48 sizes, units have precise mechanical dimensions which stand up to continual resetting of screw. Excellent electrical qualities include stability and elimination of

drift or other phenomena in electronics use. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

Circle 660 on Page 19

Speed Reducer

for direct mounting on driven shaft

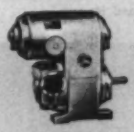
Shaftex speed reducer is available in sizes from ½ to 40 hp with nominal internal gear ratios of 5:1, 15:1, and 20:1. It is a completely enclosed unit for direct mounting on driven shaft, and is furnished in single or double-reduction units.

USE A PUTTER FOR A TWO HUNDRED YARD DRIVE?

The fellow you see here is about to learn the importance of selecting the proper club in golf. It's important, too, to select the electric power drive system which exactly meets your production requirements. When standard electric power drive systems don't, see your Sterling Application Engineer for the special design that will.

Sterling offers a wide range of Normal Speed, Geared and Variable Speed Drives and an unlimited line of Special Duty Motors.

INQUIRE TODAY



Speed-Trol Variable Speed Drives

Slo-Speed Gear Motors

Constant Normal Speed Motors

Multi-Mount Speed Reducers

STERLING ELECTRIC MOTORS Plants: LOS ANGELES 22 • CINCINNATI 12 Offices and Stocks in Principal Cities

I am interested in your application engineering service for special duty motors.

NAME_____

TITLE_____ COMPANY_____

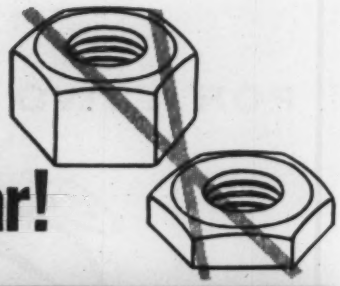
ADDRESS_____

CITY_____ STATE_____

If you have a specific project in mind, please submit details for our recommendation.

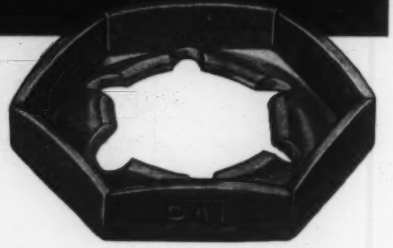
Circle 508 on Page 19

Save 65¢ on each Fastener Dollar!



Replace expensive heavy nuts and jam nuts with low-cost, vibration-proof

PALNUT TYPE R LOCK NUTS



All PALNUT Lock Nuts provide attractive savings—but in sizes from 5/16" and up, the ratio of economy increases dramatically. On many applications, Type R PALNUT Lock Nuts can do the job better, at 1/3 the price! PALNUT spring-tempered steel lock nuts provide rugged assembly for loads in shear and moderate tensile loads, in sizes up to 2½" diameter. In addition, you get the following design and cost advantages:

- Vibration-proof assemblies without lockwashers.
- Save Space—need only 3 bolt threads, permit shorter bolts.
- Save Weight—PALNUTS weigh 65% less than plain nuts, 80% less than plain nut and lockwasher.
- Precision Made—always fit screw threads.
- Fast Assembly with hand or power tools.
- Sizes from #3-48 Machine Screw through 2½" American Standard Heavy.

Above: A 5/16"-18 PALNUT securely fastens inlet nipple in airplane brake assembly.

Right: A ¾"-20 PALNUT used on base assembly of food mixer.

Above: A 1"-14 PALNUT holds rear view mirror bracket to cowl of automobile.

Write for literature and free samples, stating type, size and application.

THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.

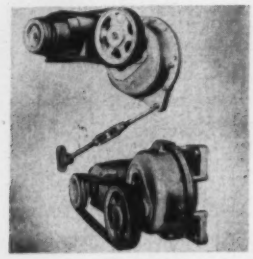
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS

PAL®

Quick, secure fastening at low cost

Circle 509 on Page 19



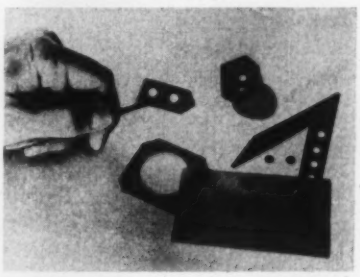
Reducer can be adapted without disassembly to include backstops where reverse rotation is prohibited and overload releases for chokable conditions. Unit is usually driven by a fixed-pitch-diameter drive. Variable speeds can be obtained by using either stationary control or motion-control sheaves. Reducer can be operated with a timing-belt drive to provide high degree of positive ratio transmission. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis. K

Circle 661 on Page 19

Epoxy Bonding Material

is unaffected by temperatures to 400 F

Filmex is a tissue-thin epoxy sheet suited for rapid assembly of parts. It provides a bond exceeding 5000 lb in shear strength, and can be used for bonding materials such as glass, ceramics, or metals. Material is unaffected by temperatures to



400 F. A translucent material, it is completely flexible and ranges in thickness from 0.0015 to 0.020 in. **Mansol Ceramics Co.**, 140 Little St., Belleville, N. J. D

Circle 662 on Page 19

Retaining Rings

stainless-steel units have excellent corrosion resistance

Truarc retaining rings are available in a high-strength, precipitation-

Circle 510 on Page 19→

A

new concept

to simplify your spring

design and purchasing problems

Select-A-Spring

ready-to-use engineered standard springs

Now you can select compression or extension springs from hundreds of ready-to-use, engineered standard-specification sizes. No fuss or paper work—no blueprints or drawings necessary. Select-A-Spring enables buyer or designer to pinpoint his needs without delay. Simply match your requirements to the Select-A-Spring list, order by catalog number, quantity and material. Especially convenient where quantities are moderate.

Select-A-Springs are pre-engineered, using wire certified to military and aircraft specifications, in various lengths, diameters, rates, and loads up to 20 lb. They meet industry and military standards. Material is either music wire or stainless steel. Compression springs are squared and ground. Extension springs have regular loops. Other ends and loops optional.

Whether your need is immediate or future, write now for the A.S.C. Select-A-Spring list. Keep it handy as a time-saving, useful spring service.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

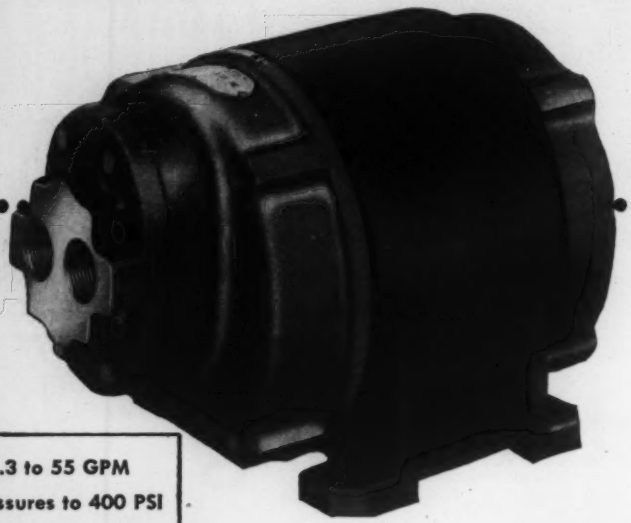
5907

They're Here!

NEW ADDITIONS TO THE

ROPER T SERIES

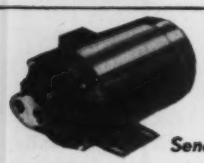
COMPACT, INTEGRAL PUMP AND MOTOR UNITS
For Hydraulic, Pressure Feed, Transfer Work



.3 to 55 GPM
Pressures to 400 PSI

NOW...A CHOICE OF 192 MODELS

Roper has expanded its line of Series T rotary pump units to take care of a wider range of uses pumping clean liquids. These "all-in-one" units, with pump serving as the end bell of the motor, are easily installed and have minimum space requirements . . . no coupling is required . . . each unit is approximately same size as standard NEMA motor of HP required for driving. For your specific application consult the Roper representative in your vicinity.



- **COMPLETE, COMPACT UNITS**
- **LOW FIRST COST**
- **MOUNT IN ANY POSITION**
- **LONG LIFE SERVICE**
- **LIGHT WEIGHT**

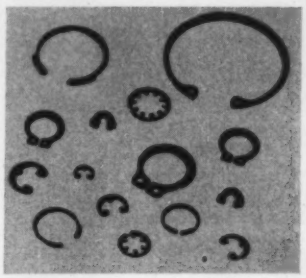
Roper Series T units are available in short, low and larger units with open drip proof or totally enclosed motors, single or three phase as required. Typical applications include: hydraulic door openers, work table movement, hospital beds, dental chairs, general transfer, as well as metering jobs on a wide variety of applications.

Send for Bulletin 31

ROPER HYDRAULICS, INC.
242 Blackhawk Park Avenue
Rockford, Illinois

ROPER
ROTARY PUMPS

hardening, stainless-steel alloy which provides excellent corrosion resistance at temperatures to 1000 F. The new material brings to six the number of metals in which rings are furnished: high-carbon spring steel; aluminum; beryllium copper; phosphor bronze; AISI Type 420 stainless steel. Similar in corrosion resistance to the 300-series stainless steels, the new material can be hard-



ened to provide spring characteristics necessary for retaining-ring application. High strength-weight ratios make possible excellent strength and heat resistance with minimum weight. Dimensions for rings of the new alloy are identical to plated carbon spring-steel and Type 420 stainless-steel rings. **Truarc Technical Service, Waldes Kohinoor Inc.,** 47-16 Austel Place, Long Island City 1, N. Y. C

Circle 663 on Page 19

Pillow Blocks

are permanently lubricated

Pillow blocks permit bearing to adjust to shaft misalignment and still maintain full contact seating of bearing in housing. Blocks fit standard inch shaft dimensions and are interchangeable with most other pillow-block installations. Ball bearings used are prelubricated, eliminating any further lubrication.

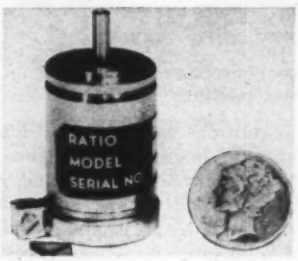
Lubricant is retained in bearing by Labri-Seal, which combines advantages of a rotating flinger, labyrinth seal, and positive-contact, synthetic-rubber seal. Positive locking on shaft is accomplished by a cam-action locking collar which engages an eccentric land on bearing inner ring. After collar is positioned and set screw is tightened on shaft, locking collar becomes tighter as shaft rotates. Blocks are available in all standard shaft sizes up to 1 15/16 in. **Marlin-Rockwell Corp.**, 402 Chandler St., Jamestown, N. Y. N

Circle 664 on Page 19

Servomotor Gearhead

miniature unit adapts easily to Size 8 motor

No. 760GH servomotor gearhead is a clamp-equipped miniature unit which adapts instantly to Size 8 motors. Double-lipped clamp imparts rigidity to over-all assembly and provides uniform clamping pressure which will not cause warp-



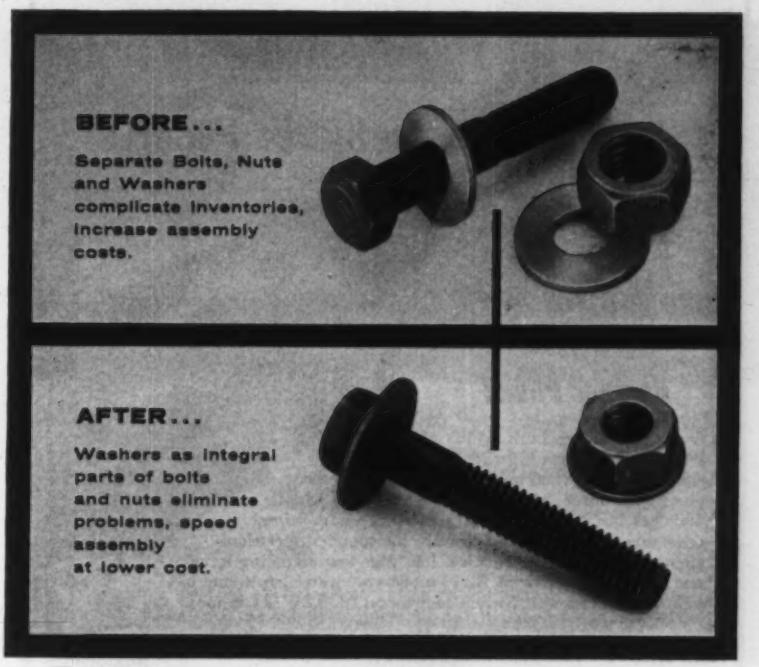
age or other uneven strains. Internal post-type construction has been eliminated, which also serves to increase rigidity and improve vibration and shock resistance. Accuracy and permanency of component alignment are increased with new construction. **Bowmar Instrument Corp.**, 8000 Bluffton Rd., Ft. Wayne, Ind. J

Circle 665 on Page 19

Positioning Switch

eliminates hysteresis in control action

Use of a responsive ball valve in new positioning switch eliminates lags between switch and actuator mechanism. Switch is 20 per cent smaller than earlier models, allowing more compact flush or surface mounting on panel boards. It is


BEFORE...
Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.
AFTER...
Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

Save Money

by simplifying fastener design

Here is a simple application of a basic bolt making principle which is affecting substantial savings for a number of manufacturers.

These savings, resulting from simplified design, are realized in every step of the operation from lower first cost of the fasteners through inventory to final assembly. Totalled, they are well worth while.

There are many other basic principles . . . often overlooked in designing and specifying fasteners, which are of importance cost-wise.

You'll find them in our new booklet, "How to specify fasteners . . . and save". Filled with drawings and charts, it makes a handy guide in designing or buying any headed parts.

If you can use a copy, write to North Tonawanda or ask a Field Representative.

BUFFALO BOLT COMPANY

Division of Buffalo-Eclipse Corporation

North Tonawanda, N. Y. • Princeton, Illinois

MAKING BOTH FASTENERS AND FRIENDS FOR 100 YEARS

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Circle 512 on Page 19

LOXSWITCH

—by the Hundreds!

FORD MOTOR COMPANY Bumper Plant!

Over 500 Denison LOXSWITCH Heavy Duty Limit Switches provide reliable switch control for Ford's new multi-million dollar bumper plant at Monroe, Michigan. LOXSWITCH Limit Switches last for millions of actuations under severe operating conditions. They feature the soundest electrical circuit, the longest mechanical life, plus low actuating force and 70° safety overtravel. All 13 models are water-, dust- and oil-tight at no extra cost! Switch to low-cost LOXSWITCH today.

FREE CATALOG 956 describes single pole-, double pole, multiple circuit and neutral position switches. Send for complimentary copy.

R. B. DENISON MFG. CO.
102 ST. CLAIR AVE., N.W. • CLEVELAND 13, OHIO

SPECIALIZING EXCLUSIVELY IN LIMIT SWITCHES

Circle 513 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency. $1.00 per copy

A MACHINE DESIGN REPRINT

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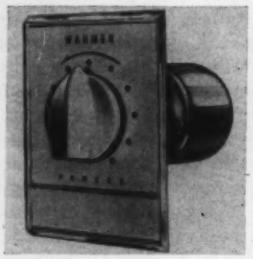
(Remittance or Company Purchase Order must be enclosed with order)



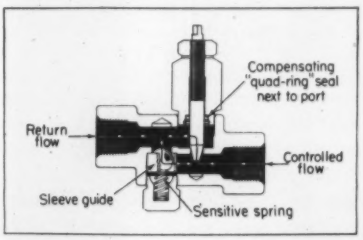
used primarily for remote control of pneumatic valves or damper motors. Turning switch knob gradually increases or decreases flow of compressed air to these devices, opening or closing them to desired position. Including face plate, switch is 2⅜ in. wide x 3⅜ in. high x 2¼ in. deep, and is available for either flush or surface mounting. Body air connections are for 1/16 in. NPT. Switch is supplied with flexible air hoses having terminal connections for ¼-in. OD tube. **Powers Regulator Co.**, 3462 Oakton St., Skokie, Ill. I

Circle 666 on Page 19

Flow-Control Valves

have oversize ports and passages

Flow-control valves, with forged aluminum bodies, are designed to produce optimum control and sensitivity in both oil and air applications. Oversize ports and passages, which insure minimum pressure drop and loss of power, make valves suitable for hydraulic circuits where maximum flow is required for greatest efficiency. Valves are designed for pressures to 3000 psi. Body combines a sensitive check valve, which permits full flow in one direction, with a long, tapered, pointed vernier thread needle which provides wide range of flow adjustments in opposite or controlled direction. Compensating-type pressure gland permits flow adjustments under full rated operating pressures. Valves



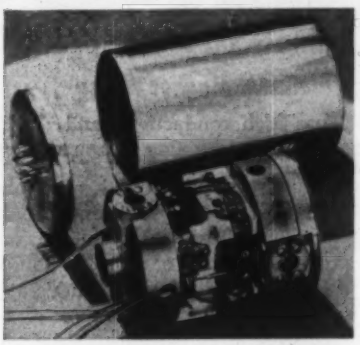
are available in standard, dial, and knob types for in-line mounting, and in dial and knob types for panel mounting. Units are available in five female pipe sizes from ⅛ to ¾ in. **Auto-Ponents Inc.**, 3001 Grant St., Bellwood, Ill. J

Circle 667 on Page 19

Dual-Rate Gyro

measures rates about two different axes

RG-18 dual-rate gyro has one motor which is used to drive two separate wheels, making it possible to measure rates about two different axes. Gyro incorporates two independent pickoffs, one for each axis



or one for each range. It meets tough environmental conditions such as temperatures from −65 to 180 F while operating, 100 per cent relative humidity, and unlimited altitude. Unit has excellent resistance to acceleration, vibration, and shock. **Humphrey Inc.**, 2805 Canon St., San Diego 6, Calif. L

Circle 668 on Page 19

Hose Assemblies

have permanently attached ends

Krimp-lok hose assemblies, composed of various types of industrial hose to meet a range of requirements, incorporate permanently attached ends. Hose materials include wire-inserted woven rayon, rayon braid, steel-wire single and double braid, and steel-wire, spiral-reinforced hose for low, medium, and high-pressure hydraulic and pneumatic applications. Special liner materials are available for special mediums. Threaded end-fitting connections include male pipe, swivel male pipe, 37-deg flare, 37-deg swivel

Ball retainers of antifriction

RULON A*

add extra life and extra use to antifriction bearings

A well-known bearing manufacturer, after testing many metallic and non-metallic materials for use as ball retainers, standardized on Rulon A to insure far greater service life for their bearings. Dixon's "superTeflon" contributes many performance advantages in this application:

- Because of its low coefficient of friction, the Dixon-supplied retainers help keep frictional heat to a minimum, guarantee low starting torque, and smooth vibration-free performance.
- Due to its engineered reinforcing, Rulon A provides high resistance to wear and deformation under load . . . assuring precise spacing of balls.
- Because of high thermal and chemical adaptability of Rulon A, the manufacturer now can offer bearings for the widest variety of service conditions. Rulon A retains its mechanical properties over −450°F to +550°F temp. range . . . has practically universal chemical inertness.
- The Rulon A retainers serve a dual role, having the ability to run completely dry—or to greatly extend performance with the use of lubricants.

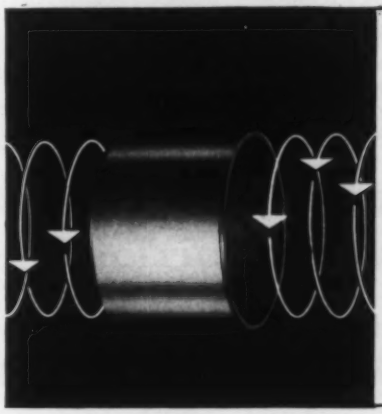
As in the development of these efficient ball retainers, Dixon's research and engineering groups are ready to assist design engineers in the successful and profitable application of Rulon to their products. Knowledge of standard or special reinforcing additives plus a broad experience in the manufacture of molded, extruded, or machined parts make Dixon the ideal source for sleeve bearings, bushings, thrust bearings, wear strips, cam followers, relay pushers, torque control bushings, and many other mechanical and electrical components. *One of Dixon's many modifications of Du Pont TFE Teflon

Write for Engineering Data Sheets on **RULON**

DIXON Corporation, Bristol, R. I.

Dixon

Suppliers of basic shapes and fabricated parts in Rulon and Teflon



Shafts run smoother and longer on RULON T-LINER BEARINGS

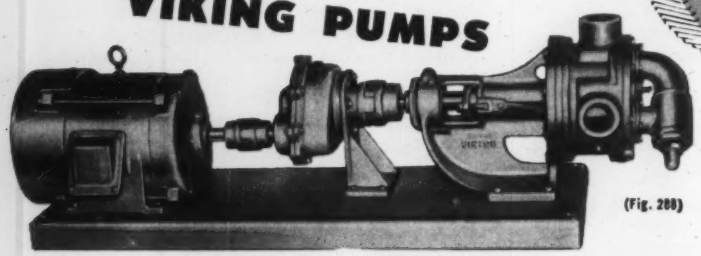
Dixon's T-Liner Sleeve Bearing . . . with antifriction "floating" Rulon insert (modified TFE Teflon*) . . . is designed for applications that require high wear resistance with no lubrication. Available from stock in 10 standard sizes for ¼" to 1¼" shafts. Bulletin 32-T gives full details on coefficient of friction (low!), chemical inertness (high!), and price (low!). Write **Dixon Corporation, Bristol, Rhode Island.** *Du Pont TM

Dixon

Circle 514 on Page 19

Circle 515 on Page 19

NEW! HELICAL
Gear Reductions on
VIKING PUMPS



(Fig. 288)

35 - 50 - 90 - 150 G.P.M. Sizes

Addition of helical gear reductions makes Viking heavy-duty pumps more compact. Five gear reductions, easily interchanged, permit a wide range of pump speeds for handling thick or thin liquids. Gears run in a bath of oil, making quiet operation. Reducers are self-supported, not hung on pump or motor shaft.

If you're looking for a rugged work horse kind of pump that is narrow and low and will fit into small space, these new Viking heavy-duty units will interest you.

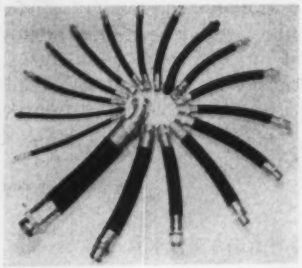
For full information, write for bulletin SP-488 H.

VIKING—the leader, not a follower, in Rotary Pumps

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

See Our Catalog in Sweets' Product Design File

Circle 516 on Page 19



nut, 45-deg flare, 45-deg swivel nut, and straight for SAE O-ring boss. Straight and angle four-bolt, split-flange end connections are also offered. Heavy-duty assemblies have been tested at pressures to 7500 psi. **Fittings & Hose Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 669 on Page 19

Aluminum Magnet Wire

has high conductivity and improved winding characteristics

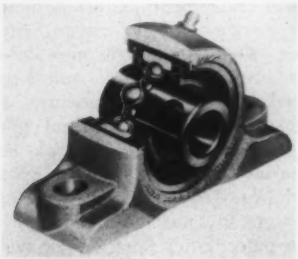
Aluminum magnet wire is available in a broad range of sizes, shapes, and insulations. Use of aluminum produces savings of from 15 to 35 per cent over equivalent conducting lengths of copper wire in most common sizes. Wire has improved winding characteristics, and excellent performance at high temperatures. Both film and fibrous insulations are offered in operating temperature classes A, B, F, and H. Aluminum processing permits high conductivity (62.7 per cent IACS). **Kaiser Aluminum & Chemical Sales Inc.**, 919 N. Michigan Ave., Chicago 11, Ill. J

Circle 670 on Page 19

Pillow-Block Bearings

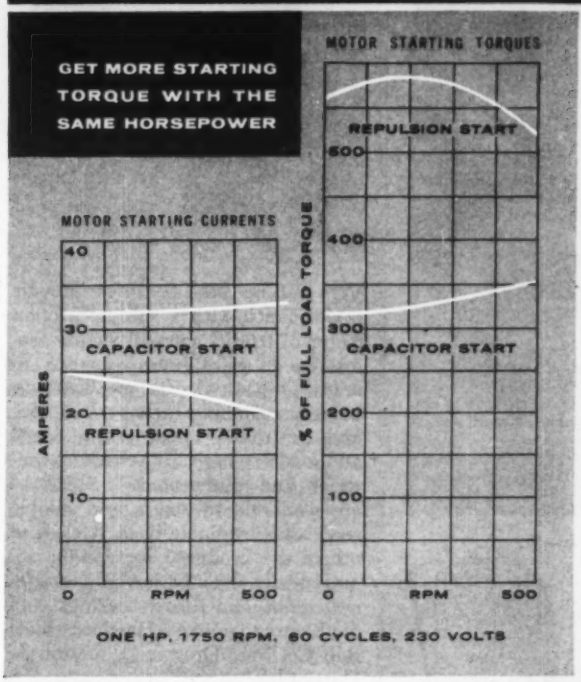
incorporate synthetic rubber cushion

Pillow-block ball bearings, designed for applications where extremely quiet operation is essential, incor-



TOUGH STARTS MADE EASY...

WAGNER REPULSION-START INDUCTION MOTORS



START HEAVY LOADS WITH EASE

STAND UP UNDER LONG SERVICE

USE EXTREMELY LOW STARTING CURRENT

Starting heavy loads is a natural for Wagner Type RA Motors. Widely used for high starting torque applications, like farm machinery, compressors, pumps and grinders, this rugged single phase motor requires very low starting current that minimizes light flicker. You get smooth performance with a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough single phase applications with these motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

You can get these motors from leading motor distributors in your community or through Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-220 gives full details on Repulsion-Start-Induction Motors.

WM59-8

Wagner Electric Corporation

6404 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

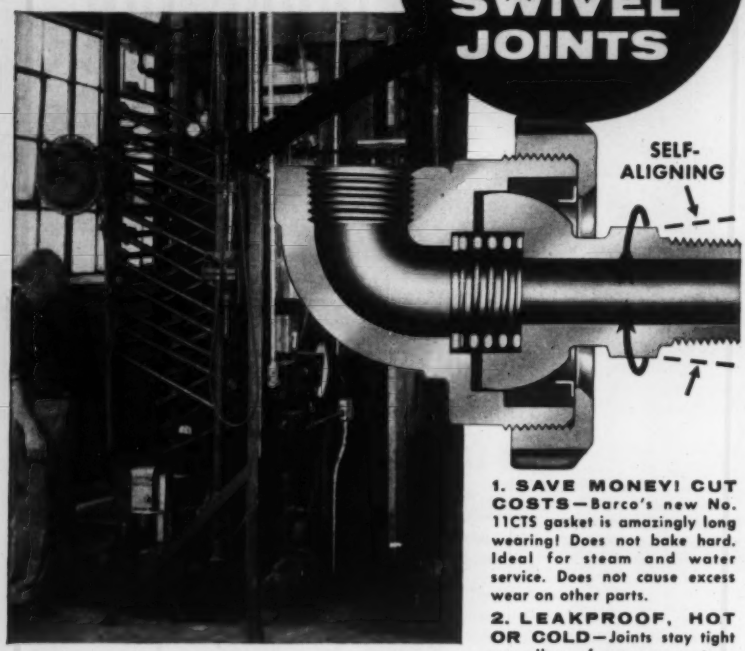
SERVING 2 GREAT GROWTH INDUSTRIES . . . *ELECTRICAL* . . . *AUTOMOTIVE*

For Multiple Platen Laminating Presses

THE RICHARDSON COMPANY
MELROSE PARK, ILLINOIS

In appraising production capabilities of new laminating presses, The Richardson Company places maximum emphasis on condensate drainage to insure accurate, uniform temperature control. Barco Swivel Joint piping connections help meet this requirement.

—Installs BARCO *Self-Aligning* SWIVEL JOINTS



THE RICHARDSON COMPANY of Melrose Park, Illinois, has long been recognized as one of the nation's outstanding operators of molding and laminating press equipment. Utmost care is used in selection and installation of plant machinery. Particular attention is given to the installation of large multi-platen laminating presses. On these, Richardson production engineers wanted a neat, reliable arrangement for steam and water connections to closely spaced movable platens.

The answer (see photo above) was to install 1" Barco Type S self-aligning, all-bronze Swivel Joints in metal "dog leg" piping. Each line is precisely positioned for perfect steam flow, with no "low spots" to trap condensate. Lines "nest" together when press is closed, yet move readily without interference when press opens. Operating experience has demonstrated that the joints stay tight without leakage and with no danger of blow-outs. When desired, the joints easily handle alternate flow of hot steam and cold water.

IT PAYS TO USE BARCO SWIVEL JOINTS!

1. SAVE MONEY! CUT COSTS—Barco's new No. 11CTS gasket is amazingly long wearing! Does not bake hard. Ideal for steam and water service. Does not cause excess wear on other parts.

2. LEAKPROOF, HOT OR COLD—Joints stay tight regardless of pressure or temperature.

3. SELF-ALIGNING—10° side flexibility. This Barco feature saves piping time, cuts costs, and insures perfect performance.

4. ENGINEERING RECOMMENDATIONS—Send for a copy of Catalog No. 265C and installation drawing 10-52004.

SEND FOR CATALOG 265C

FOUNDED 1903 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.
506C Hough Street • Barrington, Illinois

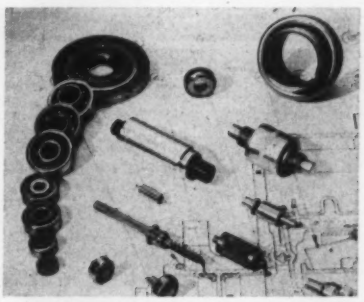
The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

porate an oilproof synthetic-rubber cushion between bearing outer ring and pillow-block housing to insulate against vibration and suppress noise. Housings are a lightweight, ductile material that resists shock and vibration. Units are available in five shaft sizes from ½ through 1 in. Component machine unit bearing of pillow blocks is also available as a separate unit. It consists of a prelubricated, single-row bearing with large balls and deep raceways, plus two seals and wire lock ring for use in mounting. OD of bearing is enclosed with oilproof cushion. **Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich. H

Circle 671 on Page 19

Ball Bearings

are designed and produced for special requirements



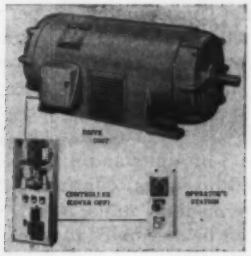
Vers-O-Line ball bearings provide performance with a specific friction factor of 0.0015 against friction factors up to eight times as much in many types of sleeve bearings. Bearings combine high performance and controlled tolerances. Speed and load are basically related to material and dimensions. Bearings are available in single and double row, some available from stock, and others are produced for specific requirements. These include single-row radial and thrust bearings, and double-row units. **Hartford Steel Ball Co. Inc.**, Drawer Q, Station A, Hartford 6, Conn. B

Circle 672 on Page 19

Adjustable-Speed Drive

has no brushes, commutators, or slip rings

Adjusto-Spede drive is available in ratings from ¾ to 7½ hp with a stationary field construction. All



brushes, commutators, and slip rings have been eliminated to substantially reduce maintenance. Redesigned construction also reduces length of drive up to 22 per cent. Ac motor and eddy-current clutch are built into a common housing. Motor end brackets are interchangeable with standard flanges, and units can be flange-mounted to driven machine for further space saving. Drive is designed to supply precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and similar equipment. It is suitable for continuous operation at full load (constant torque) in ranges to 34:1 and for intermittent use from zero to full speed. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 673 on Page 19

Speed Changer

provides instant speed variations

Vari-Tex speed changer is offered in horizontal and vertical units for smooth, instant speed variations. Four-position motor mounting and two-position gear mounting make it possible to adapt unit readily to varying space conditions. One-piece motor and driver sheave shaft, supported between bearings at ends, reduces shaft deflection and increases efficiency. Over-all electrical input to mechanical output ef-

Circle 519 on Page 19→

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Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

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LONG LIFE • LASTING ALIGNMENT

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Dept. E, MANHASSET, NEW YORK

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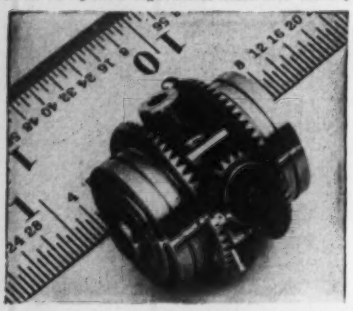
MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

MINIATURE BEARINGS AND GEAR DIFFERENTIAL BACKLASH

(NOTE: We are grateful to W. J. Opocensky, Staff Engineer, Librascope, Inc., Glendale, California, for his factual report on the part played by our bearings in the design of the small two-pinion differential illustrated below.)



LIBRASCOPE 3/16" HOLLOW SHAFT DIFFERENTIAL uses special duplex MICRO-BEARINGS in all gears. Specifications are: Working circle 1.090", Length .980"; Input gear hole size .687", Starting torque .2 in. oz.—Maximum backlash 5 min. at 2 in. oz.

Miniaturization of precision ball bearings and gears is well advanced. However, putting them together to produce a small differential with low torque and backlash of five minutes or less is no simple task. Loads on single pinion differentials and on single ball bearings introduce objectionable flexibility. So does uncontrolled radial play in ball bearings whether used singly or in pairs.

After considering many designs, Librascope selected a two-pinion differential as the most logical type to develop. A "hunting tooth" gear ratio was also chosen to distribute wear evenly. Double bearings preloaded were to be used in all gears.

Special miniature bearings were developed to give duplex bearing performance at a cost only slightly higher than regular catalog prices.

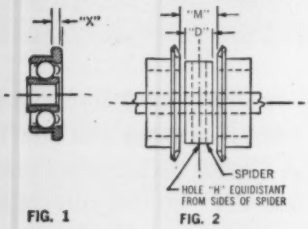


FIG. 1 FIG. 2

Dimension "X" in *Fig. 1* is coded in increments of .0002" under given axial load.

In *Fig. 2* the mounting distance "M" of the bevel gears is known. With the new bearing dimension "X" it is possible to determine the "spider" dimension "D". This provides the desirable mounting distance of bevel gears without shims.

To obtain maximum distance between raceways in limited space, narrow unshielded bearings were selected. To provide dust protection for the bearing a thin shim slightly smaller than the I. D. of the outer bearing race is used between bearing and Truarc ring. Truarcs are stainless steel double-disc-ground to various specific dimensions. With all dimensions controlled, bevel gears are accurately located from the pinion shaft hole, and any desired preload in the bearing can be obtained by selecting a Truarc of proper thickness.

Control of radial play of bearings in pinions presented a different, though similar, problem. Space limitations in the pinion are much more severe than with bevel gears. *Fig. 3* shows how Librascope solved the problem. Dimension "X" is coded in increments of .0001" with a given axial load, from inner race to outer race opposite the flange side on the one hand and opposite the ball retainer side on the other. A precision shim is used between outer races of the two bearings. By selection and use of new coded dimensions, any desired preload of bearings is obtained by fitting bearings to the shim.

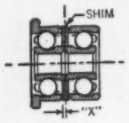


FIG. 3

To keep bearing races in mutual contact, another novel idea is used. Each pinion has its own adjustable shaft. The outside end of the pinion shaft is fitted with a Truarc. This rests against inner race of outside bearing. To overcome the limited adjustment of shims and expensive labor costs, a unique adjustable washer is used. By means of a special tool, each pinion may be adjusted for any desired amount of backlash. Bearings are held at preload by adjustable washer and Truarc. A clamping means secures pinion shaft to "spider".

The Librascope differential design makes possible "5 minute" differentials at 2 in. oz. loads. Measurements are taken at *eight* equally spaced positions for one full turn of the "spider". The maximum backlash recorded determines classification of differential.

DESIGN HANDBOOK OFFERED FREE

You'll find this 70-page authoritative publication helpful in solving problems in designing instruments of small electromechanical assemblies. Write:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

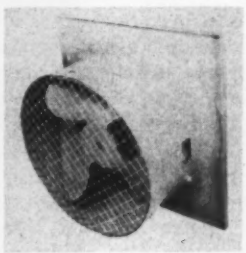
Circle 520 on Page 19

ficiency approximates 78 per cent. Since changer is designed primarily for constant-torque applications, speed ratios depend on size. Four case sizes are provided with maximum speed ratio of 10:1 in 1, 1½, 2, and 3-hp units and 4:1 in 40, 50, and 60-hp units. Maximum ratios of intermediate units is 6:1. Each unit can be assembled to provide intermediate ratios of 5, 4, 3, and 2:1, using an 1800 or 1200-rpm standard squirrel-cage motor. Single, double, and triple-reduction gears provide speed variations in low-speed range. **Allis-Chalmers Mfg. Co.,** Milwaukee 1, Wis. K

Circle 674 on Page 19

Axial-Flow Fan

delivers up to 430 cfm



Model Y1241-3 axial-flow fan is suitable for cooling electronic cubicles and flushing racks and cabinets. The 1/150-hp motor at 1550 rpm delivers 430 cfm. It operates from 115-v, single-phase, 60-cycle 11½ x 5 5/32 in. **Air-Marine Motors Inc.,** 369 Bayview Ave., Amityville, L. I., N. Y. D

Circle 675 on Page 19

Polyester Resin

for fabricating glass-fiber reinforced parts

Laminac 4104 polyester resin is available for service at temperatures to 400 F. Resin is suitable for applications such as heating ducts, particularly in aircraft, and for other structures subject to considerable heat. Typical glass cloth or glass mat laminates have adequate initial strength and show no fall-off in strength after 96 hr exposure within temperature range of 350 to 400 F. **Plastics & Resins Div., American Cyanamid Co.,** 30 Rockefeller Plaza, New York 20, N. Y. D

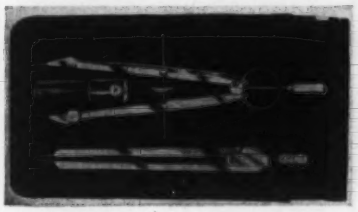
Circle 676 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Pocket Drawing Kit

contains bow compass and friction divider



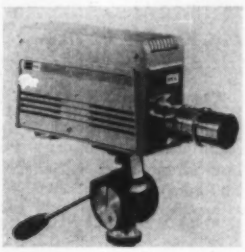
Vinyl plastic case, 6¼ x 3½ in., contains two basic instruments necessary for layouts and measuring. Full 6-in. bow compass and 5½-in. friction divider are constructed with polished-nickel finishes. Also included are a spare-parts tube and an extra divider needle. Pocket in rear of case provides additional storage space. **Alvin & Co. Inc.**, Windsor, Conn. B

Circle 677 on Page 19

Television Camera

lightweight unit withstands noise to ± 145 db

Model 1986CN closed-circuit television camera is a lightweight unit for use on rocket or jet engine test stands. It is designed to operate in noise environments up to ± 145 db without an acoustical housing, and with a housing it is virtually impervious to noise of any level. It has been used successfully in sound levels above 190 db. Unit is essentially free of microphonics. It features a video-signal amplifier



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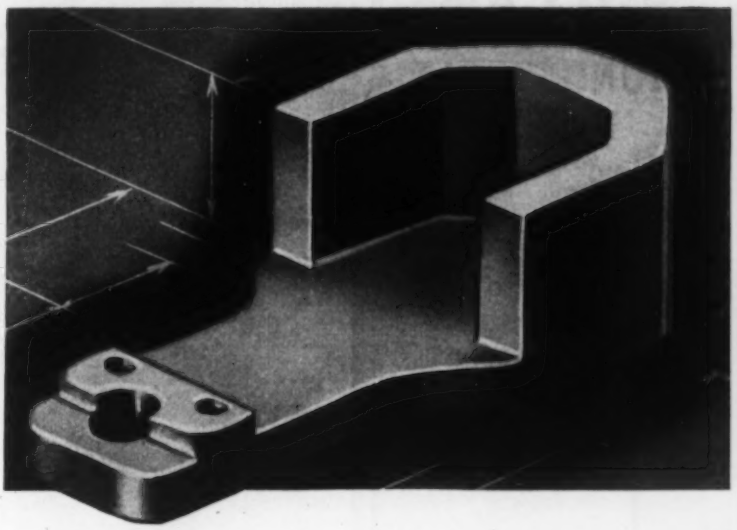

The photograph shows a bearing support plate for a new line of power tools manufactured and marketed by a large and very capable organization.

The complex nature of the part is apparent at a glance and the cost of machining such a part is evident to the eye of engineer and designer.

It is on parts of this nature that powder metallurgy offers its greatest advantages and its greatest opportunities for the future.

Such parts require most careful designing of the tooling from which they are produced, plus painstaking and tedious effort until the part can finally be produced in volume.

A manufacturer with such requirements naturally turns to Bunting where the necessary persistence until success is achieved is one of the Company's recognized characteristics.

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Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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Variety of lengths are available from 1¼" to 10" in ⅜", ½" or ⅝" diameters. Standard length of lead wires is 10".

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Company.....
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City & State.....

Circle 522 on Page 19

with subminiature tubes mounted in a heat sink. Result is a dampening out of sound vibrations, plus full thermal protection. Camera provides full 600-line resolution, and has picture of high definition. Used with a camera control unit, it automatically adjusts to changing light conditions over 2000:1 range. Unit weighs 7 lb. **Kin Tel Div., Cohu Electronics Inc.**, 5725 Kearney Villa Rd., Box 623, San Diego 12, Calif. L

Circle 678 on Page 19

Breadboard Components

are miniature units

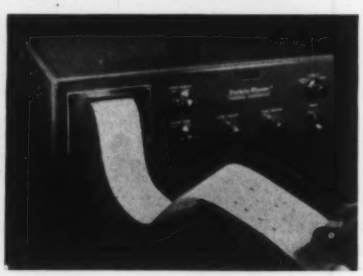
Line of miniature, precision, breadboard components consists of breadboard plates, shaft hangers, shaft collars, shim spacers, and gears in fine pitch series (96, 120, and 200 pitch). Components are available from stock. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 679 on Page 19

Printing Integrator

prints digital integrals of recorder chart data

Model 194 printing integrator is applicable wherever simultaneous integration of recorder chart readout is needed. Typical uses include: integration of stress-strain curves for determination of cyclic and rupture energies; continuous process weighing, where integrator totalizes



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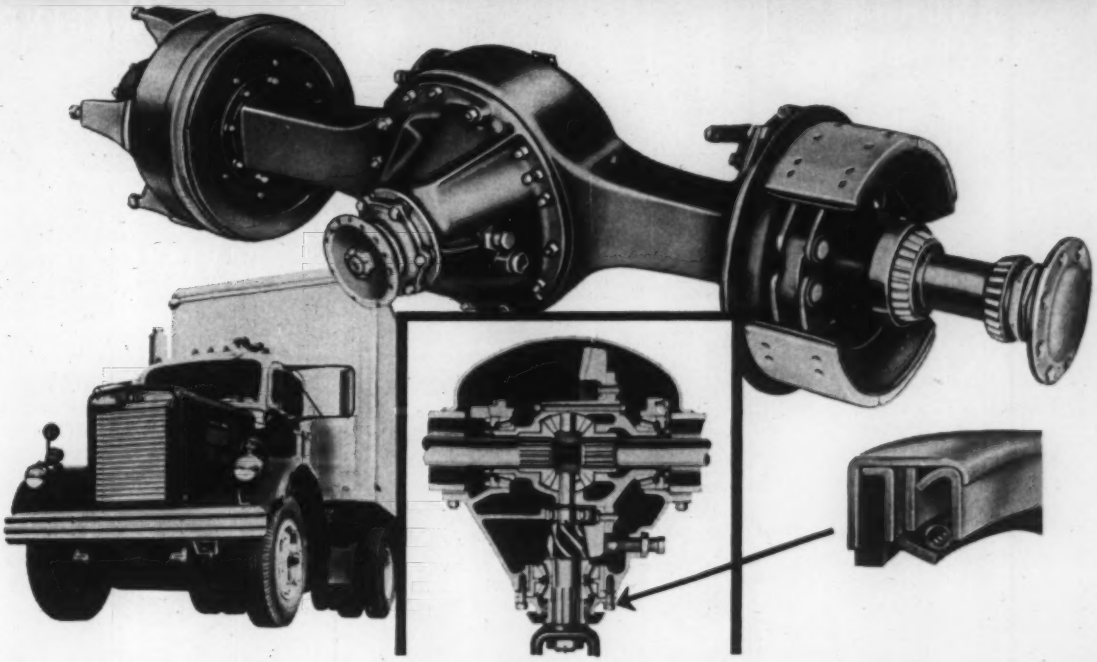


How White Trucks employ dual-lip National seal to protect axle pinion assembly

The use by the White Motor Company of a National 15,000 series oil seal in their 189C Single Reduction Rear Axle is a skillful employment of a standard-design seal to attain dependable and economical sealing.

Conditions at the sealing point are: S.A.E. 90 gear oil to be retained, dirt and water to be excluded, temperatures —20° to 180° F with normal operation at 150° F, maximum shaft speed 3,500 rpm, eccentricity and runout .002, shaft diameter 2¾", 15 RMS finish. Operation is of course intermittent with servicing conditions generally good.

Rather than two seals to respectively retain lubricant and exclude foreign matter, White engineers specified National 15004, a dual-lip Micro-Torc leather and felt seal wherein the leather sealing lip is spring-tensioned and faces inward to retain gear oil and the other felt lip is a wiper excluding dirt and dust.

National 15004 is but one of 2,500 different standard design seals National provides. For complete information on leather, synthetic rubber or other seals, call your National Applications Engineer. Look under Oil Seals, in the Yellow Pages.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California;
Plants: Van Wert, Ohio, Downey and Redwood City, California

Before specifying seals, consider all these points!

Shaft RPM, Runout, Endplay
Is seal rated at or above anticipated operating extremes?

Temperature, Lubricant Types
Will heat or special-purpose lubricants attack sealing lip material?

Presence of Dirt, Foreign Matter
Point often overlooked. Should dual-lip or double seal be used?

Cost Related to Seal Design
Will a simpler, cheaper seal do as good a job as a more sophisticated design?

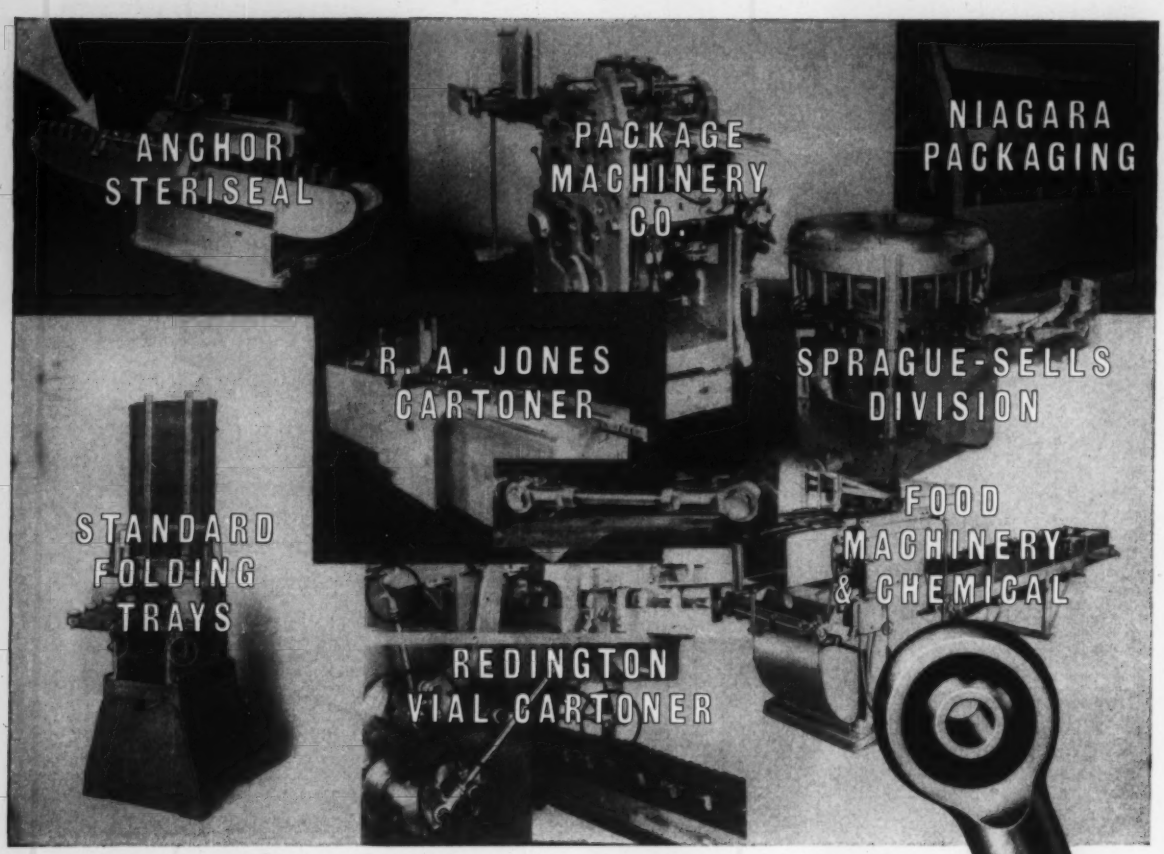
New Seals and Material Available
Are there new materials or compounds which can do the job better?

Special Design Oil Seals
Not all problems can be met with stock seals. Is special factory design indicated to meet special problems?

Delivery, Reputation
Is my proposed resource noted for good delivery, uniform quality and good follow-up service?

Don't specify "blind." Your National Seal Applications Engineer has up-to-the-minute oil seal information. Ask him—before you specify. Takes only a phone call; no obligation!

4954



Manufacturers of Packaging Machinery specify . . . .

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Cartoning machines fold package inserts and assemble them with the bottle or vial, insert them in a carton and deliver the finished package ready for shipment.

Rotary Fillers draw liquid or semi-liquid materials into a cylinder and discharge them, in accurately measured amounts, into containers.

Casers assemble a load of cans, and insert the load into a case — at unusually high speeds.

The Steriseal machine is used for high production steam vacuum sealing of glass containers.

Bottles, jars, tubes, and a variety of articles are fed from the labeling machine to the cartoner which opens the folding box, inserts the contents, then tucks and delivers the complete package.

The Cigar Wrapper-Bander cellophane wraps and bands cigars faster than two a second.

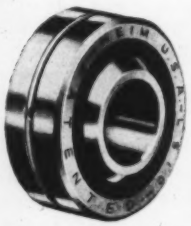
Folding trays, for tomato packaging and other types of fruits and vegetables, are formed from flat stock.

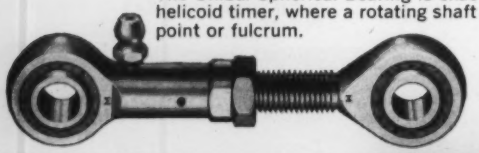
Imprinting of the package is done in one pass through some machines.

The motions involved in the push-pull linkages of this automated machinery are intricate and ingenious. Heim Unibal Spherical Bearing Rod Ends are used where it is necessary to correct inherent misalignments, and where close accuracy of fill and smooth operation at each station are mandatory.

They are used as suspended bearing supports for belt rollers. They change motion from vertical to horizontal plane, and vice versa.

The Unibal Spherical Bearing is exactly right as the support on one end of a helicoid timer, where a rotating shaft moving in all directions requires a focal point or fulcrum.





Quick and simple push-pull linkage assemblies are possible with one female threaded and one male threaded Unibal rod end. There is practically no limit to the length of linkages possible.

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THE HEIM COMPANY

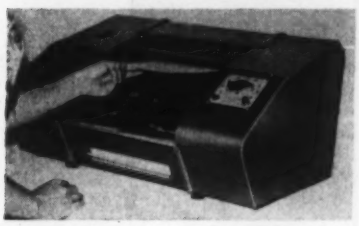
FAIRFIELD, CONNECTICUT

amount of material supplied to a conveyor belt; integration of rocket thrust in conjunction with transducers to obtain propusion efficiency. Instrument automatically prints out digital integrals of chart area measurements at a rate up to 6000 counts per minute. Designed for use with self-balancing potentiometer recorders, it gives printed numerals on standard adding-machine tape, and can be operated automatically or manually. In automatic operation, integrator prints digital integrals as curves or peaks appear on a recorder chart. Integrator tape travels continually at same rate as chart paper, so that tape and chart records later can be compared side by side. **Perkin-Elmer Corp.**, Danbury Road, Norwalk, Conn. B

Circle 680 on Page 19

Photocopy Machine

uses silver-photography process



Quick Silver photocopy unit utilizes a fast-development, chemical-stabilized, silver-photography process which uses only a single sheet of sensitized paper to make a copy. By exposing original in contact with sensitized sheet, a right-reading negative stat (white on black) is obtained by a single pass through the unit, taking less than 30 sec. Negative stat can serve as the finished copy, or can be used as a master copy to make one or more positive copies by repeating procedure. Any number of positive copies can be made from one permanent negative. Automatic printer-processor unit is capable of copying material up to 9 in. wide of any length. Originals with information on one or both sides, as well as matter printed on opaque, transparent, or translucent stock, can be copied with equal facility. **Peerless Photo Products Inc.**, Shoreham, L. I., N. Y. D

Circle 681 on Page 19

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Circle 525 on Page 19

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A

MACHINE DESIGN

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Library

Recent Books

The Algebra of Electronics. *By Chester H. Page; 258 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN; *$8.75 per copy postpaid.*

This book introduces basic dc concepts and resistance networks. Presentation of determinants and simultaneous equations leads into more complicated networks and basic ac problems. Complex numbers are treated in detail before specific electronic circuits are analyzed. Basic tubes are described and illustrated in circuit applications.

New Standards

1958 Book of ASTM Standards. *13,600 pages total; each part 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $116.00 per set of 10 vol.*

Published triennially, this set of standards covers the production, purchase, and evaluation of materials. ASTM specifications, definitions, and methods of test are used and referenced by many industries and governments.

The increase from 7 to 10 parts is due to new and expanded coverage that would have made the old divisions unwieldy. In the set are about 2450 standards. Each part is complete with a detailed subject index and a list of standards in numeric sequence. Supplements to each part will be issued late in 1959 and 1960.

Subjects and estimated availability of the parts are as follows:

Part 1—Ferrous Metals. Excludes Test Methods, 1560 pages, 290 standards, January, $12.00.

Part 2—Non-Ferrous Metals, Electronic Materials. Excludes Test Methods for Metals, 1386 pages, 251 standards, available, $10.00.

Part 3—Methods of Test for Metals. Excludes Chemical Analysis, 980 pages, 119 standards, January, $10.00.

Part 4—Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils. 1458 pages, 338 standards, January, $12.00.

here's PROOF of how the GRC method cuts the cost of small parts...

Compare the methods for producing these mutilated gear, cam and bushing combinations . . . for an electrical appliance timer. (Shown actual size)

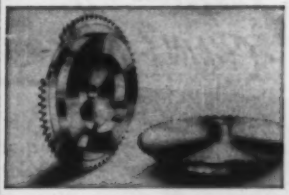
***method A**

***Stamping, screw machine part, assembly**

- Blanked, pierced, & extruded Cam
- Blanked & pierced Gear
- Screw Machined Bushing
- Sub-assembly: Stake Bushing to Gear
- Final Assembly: Stake Cam to Gear

5 PRODUCTION STEPS + 5 Inspections

the GRC method



One Piece—One Operation

Automatically Die Cast of Zinc Alloy

A BETTER PRODUCT

- Ready to use as cast
- Closer tolerances
- Higher uniformity
- No buckled gears & cams
- No loose assemblies
- No misalignment (gear-cam orientation . . . critical in this application)

SIMPLER PRODUCTION

- Cast and trimmed in one automatic step . . . no secondary operations
- No scrap loss

1 PRODUCTION STEP —only **ONE** inspection needed

NOW . . . compare these figures:

Cost/M in lots of

	100M	200M	500M	1MM
Method A	$32.50	$31.00	$30.00	$29.50
GRC Method	**17.44**	**15.50**	**12.50**	**10.00**

CLEAR SAVINGS FROM 50-60%

"BONUS FOR DESIGNERS" Only the GRC Method gives you such *complete design freedom* for small parts. It turns many "impossible-to-make-at-any-price" ideas into uniform, high quality parts . . . at lower cost. So, before you design . . . check with GRIES.

You've seen the facts . . . clear proof of how GRC's DIE CASTING METHOD offers substantial savings on your small parts. The Gries Method delivers parts of high uniformity, with close tolerances . . . ready for use as they come from Gries' automatic machines. Assembly and most other secondary operations are eliminated.

MAXIMUM SIZE: 1¾" long, ½ oz. NO MINIMUM

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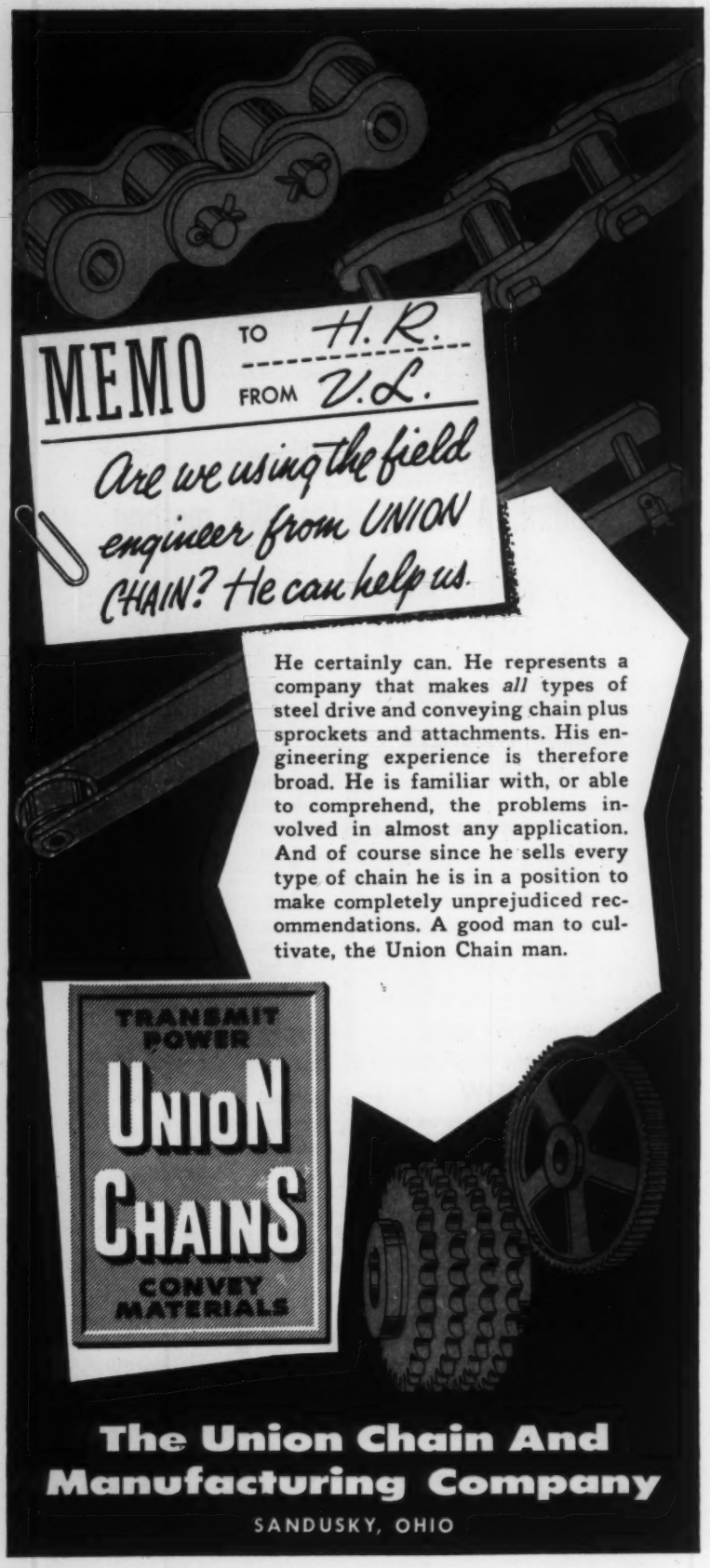
MEMO TO H.R.
FROM V.L.
Are we using the field engineer from UNION CHAIN? He can help us.
He certainly can. He represents a company that makes all types of steel drive and conveying chain plus sprockets and attachments. His engineering experience is therefore broad. He is familiar with, or able to comprehend, the problems involved in almost any application. And of course since he sells every type of chain he is in a position to make completely unprejudiced recommendations. A good man to cultivate, the Union Chain man.
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UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

Part 5—Masonry Products, Ceramics, Thermal Insulation, Sandwich and Building Constructions, Acoustical Materials, Fire Tests. 1176 pages, 226 standards, February, $12.00.

Part 6—Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather. 1152 pages, 210 standards, February, $10.00.

Part 7—Petroleum Products, Lubricants, Tank Measurements, Engine Tests. 1420 pages, 227 standards, January, $12.00.

Part 8—Paint, Naval Stores, Aromatic Hydrocarbons, Coal, Coke, Gaseous Fuels, Engine Antifreezes. 1424 pages, 353 standards, March, $12.00.

Part 9—Plastics, Electrical Insulation, Rubber, Carbon Black. 1680 pages, 290 standards, January, $14.00.

Part 10—Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes. 1532 pages, 267 standards, January, $12.00.

Association Publications

Technical Societies Guide. *32 pages, 8½ by 11 in., ringbound; published by and available from I. P. A.—Technical Societies Committee, Room 1616, 41 East 42nd St., New York 17, N. Y.; $3.00 per copy.*

This Industrial Publicity Association manual references 36 technical societies and the requirements of each for paper preparation and presentation. Comments are also included on membership structure, meeting dates, subjects of interest, organization publications, and publicity policy regarding papers or articles. A general section for authors discusses manuscript requirements, oral presentation, visual aids, and reprint requests.

Government Publications

Wright Air Development Center Technical Reports. *Publications are 8¼ by 10¾ in., paperbound, stapled; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

PB 131977, Investigation of the Compressive, Bearing, and Shear Creep-Rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures. By Luke A. Yerkovich; 115 pages; $2.75 per copy. (Tests of 15 sheet, plate, and bar alloys of aluminum, steel, stainless steel, monel, and titanium.)

PB 131986, High Temperature Solid Dry Film Lubricants. By Melvin T. Lavik; 20 pages; $0.75 per copy. (Design of test machine for 800 F, 50,000 psi, 200 fpm sliding speed; literature survey on ceramics, cermets, laminar solids, chemical coatings, metal films, and organic materials; tests of four commercial and eight special lubricants.)

PB 151019, Early Detection of Fatigue in Aluminum Alloys by Ultrasonics. By Karl Sittel, Marvin Herman, and Robert C. Good Jr.; 45 pages; $1.25 per copy. (Literature survey; design of test machine and measuring equipment; preliminary testing and determination of specimen configuration.)

PB 151218, The Compressive Creep Buckling of Metal Columns, Part 5, Cyclic Loading. By A. Rudnick, R. L. Carlson, G. K. Manning; 62 pages; $1.75 per copy. (Tests of 2024-T4 aluminum alloy at 350 F and 450 F; tests of C-110M titanium alloy at 700 F and 800 F; constant load reference tests made at each condition.)

(Advertisement)

Want to be an Executive?

Management is actively looking for engineers who have the desire and ability to become administrators

by
James M. Jenks

In a sense, this is the golden age for engineers. Once buried in corporate obscurity, many of them have emerged today as likely heirs apparent to the big jobs — and the big rewards — of business and industry. One impressive indication of this growth is that money spent in research and development over the past fifteen years has increased six-fold.

Despite this stepped-up activity, however, the once disorganized scramble for engineers seems to have ended . . . at least temporarily. And perhaps it's a good thing. Actually, the more perceptive engineers had always realized that unusually high starting salaries were often illusory. The gap between money being offered beginners and the incomes of experienced men was narrowing rapidly. Further, more and more thinking technical men concluded that even top engineering salaries are low when compared with the remuneration of highly placed general executives.

A Plan to Help the Engineer Succeed

Happily, there is a route to increased incomes that is satisfying to both engineer and company alike. This route leads into *management*. It is no easy road but the rewards are great for those willing and able to follow it.

In the vast, complicated world of business the engineer has much to learn. As a manager his duties will bring him into contact with accountants and buyers, advertising men and salesmen, lawyers and other executives. A strange new set of circumstances confronts him. He must gain confidences and be understanding, learn and instruct, be sympathetic, paternal or commanding as conditions require . . . and all in the midst of a business organization about which his knowledge is limited.

Actually, it comes down to this: To succeed as a business executive, the engineer must learn the art of making decisions quickly and accurately. And this ability is, of course, directly dependent upon knowledge. The "principles" of business—while not as scientific and inexorable as those of engineering—are no less important . . . no less essential to efficient procedure.

For nearly fifty years, the Alexander Hamilton Institute has specialized in bringing this knowledge to mature men—at home in their spare time.

Free . . . "Forging Ahead in Business"

We do not claim that you must have the Alexander Hamilton Course in order to succeed in business. But we do say that *you cannot succeed without what is in the Course!*

All the Institute does is offer you a convenient and time-saving means of bringing this knowledge to you in your spare time; and in a form that has *proved* to be practical and effective.

So that you may judge for yourself whether or not you think the Institute can help you, we have published an informative 48-page book titled "Forging Ahead in Business."

We believe that this little book will help any man get down to bedrock in his thinking; however, there's no cost or obligation for it because—frankly—we've never been able to put a price on it that would reflect its true value. Some men have found a fortune in its pages.

If you would like a complimentary copy of "Forging Ahead in Business", simply sign and return the coupon below. It will be mailed to you promptly.

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Circle 528 on Page 19

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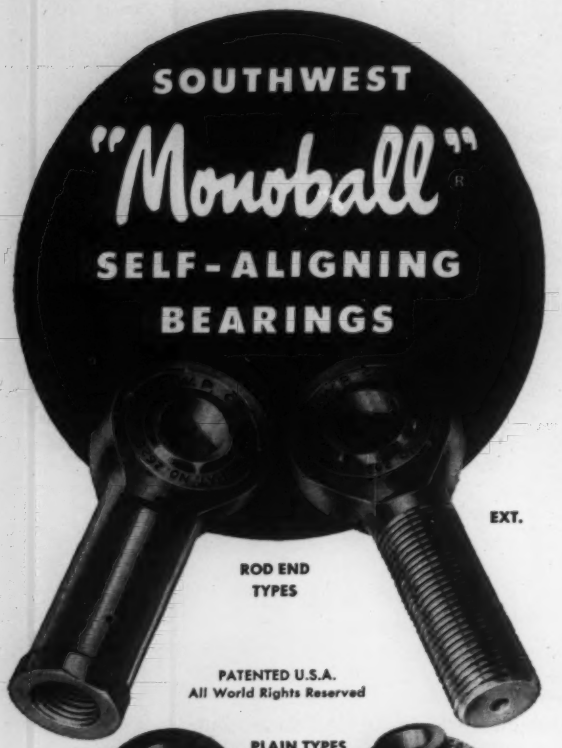
"Monoball"
SELF-ALIGNING
BEARINGS



CHARACTERISTICS

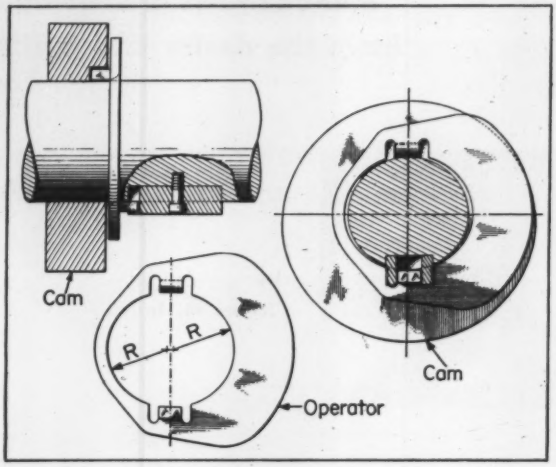
	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. MD-M59

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

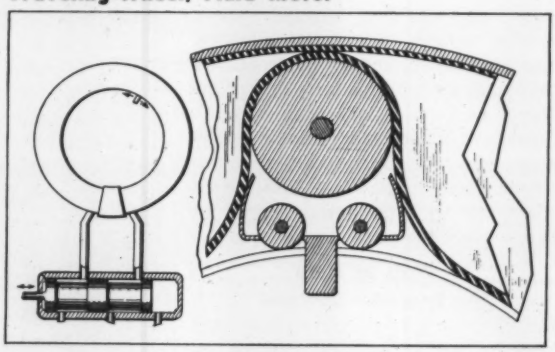
NOTEWORTHY Patents

Automatic Cam-Position Control



Loose fit and built-in imbalance enable an "operator" member of a control assembly to advance or to retard momentarily an eccentric circular cam member. The operator carries two tabs; one engages the shaft while the other engages the cam. The cam is closely fitted but free to rotate on the shaft. A hole in the operator fits the shaft closely across the tabs and loosely 90 deg from that axis. Inertia forces due to velocity change cause the operator to pivot about the shaft tab, creating a moment on the cam. Consequent rotation of the cam with respect to the shaft can be used as an automatic control adjustment. *Patent 2,864,264 assigned to Fairbanks, Morse & Co., Chicago, by Hans A. Rass.*

Traveling-Wheel, Fluid Motor



A wheeled, traveling assembly is moved in either direction along a fixed path by a gradient of fluid pressure in a flexible, closed tube. The path is defined by a rigid shell of any shape, regular or random,

NEW

Enclosed Gearmotor for Venting and Similar Applications

- Speed Range 420 to 1 RPM
- Power range minimum to 40 in. lb.
- Quiet motion—dependable power—service free
- Totally enclosed and lubricated for life
- Compact rigid construction and minimum space
- Complete power range available with 5 interchangeable motor heads and a wound shading pole reversible
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- Tell us your requirements

Joins millions of Motoresearch Gearmotors now in use!

Motoresearch also designs and produces high frequency motors, generators, rectifier type power supplies and other Special Electrical Equipment. We invite your inquiries.

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RACINE, WISCONSIN
Designers and Manufacturers of
SPECIAL ELECTRICAL EQUIPMENT

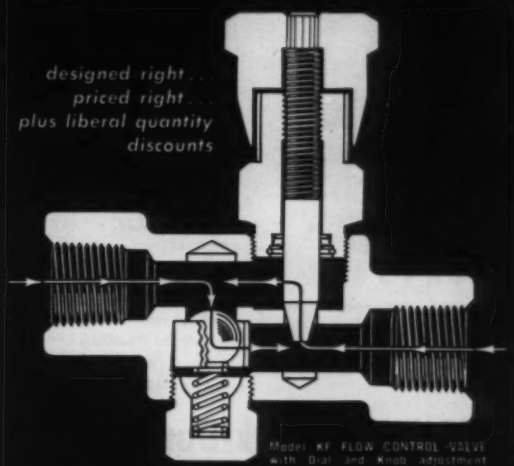
Circle 530 on Page 19

AUTO-PONENT

FULL FLOW VALVES . . .

FLOW CONTROL, NEEDLE, CHECK for Hydraulic and Air Applications

designed right . . . priced right . . . plus liberal quantity discounts



Model KF FLOW CONTROL VALVE with Dial and Knob adjustment for direct reading and duplicating flow settings. Now available in Aluminum for 3000 PSI

Model F Standard Flow Control Valve or Model N Needle Valve

A COMPLETE LINE: ⅛", ¼", ⅜", ½" and ¾" Female Dryseal Pipe Sizes (Also in same Aeronautical Tube sizes on special order)

MINIMUM PRESSURE DROP AND POWER LOSS. Oversize ports and passages permit maximum flow at minimum pressure drop, insure greater accuracy and response in the control of hydraulic or air cylinders.

Model KF Knob and Dial Flow Control Valve or Model KN Needle Valve.

FAST, EASY, FLOW ADJUSTMENTS under full rated pressure. Fine needle threads, long pointed needle with compensating type Quad-Ring pressure gland seal, permits easy needle turning, and prevents air and dirt trapping in the housing.

Model PF Knob and Dial Flow Control Valve or Model PN Needle Valve for panel mounting.

FORGED BODIES FOR GREATER STRENGTH. High tensile strength aluminum, steel, or stainless steel forged bodies permit higher pressure ratings with wide safety margin. All internal parts are stainless steel. Operating pressures: Aluminum — 3000 psi now available; steel and stainless steel — 5000 psi. (available soon)

Model C Check Valve for In-Line Mounting.

SENSITIVE, CHATTERLESS BALL CHECK incorporated in Flow Control and Check Valves opens fully or closes instantly at slightest differential pressure. Patented design permits ball area to be double the seat area, which insures accelerated ball movement and rapid opening at low differentials.

Write for new AUTO-PONENT Catalog.

AUTO-PONENTS, INC.
2925 Grant Street, Bellwood (Chicago Suburb) Illinois

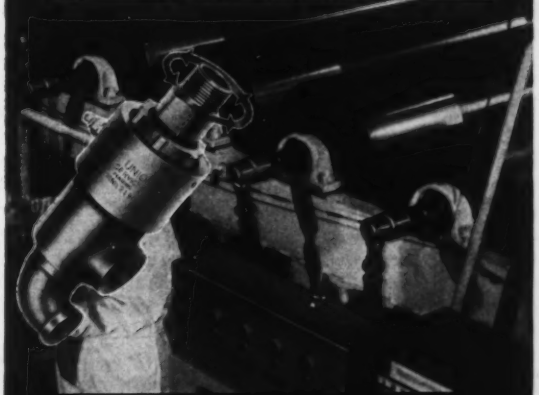
Circle 532 on Page 19

Unmatched for dependability the ROTARY UNION*

Where exact temperatures must be maintained as on this plastic film drier, the ROTARY UNION is without an equal. It is self-adjusting to pressure, self-aligning to stress and strain, and requires no mechanical adjustments. This superb rotating joint is delivering long-lasting and extremely reliable service under the most critical conditions.

Wherever rotating connections are required for heating or cooling, you will find that the ROTARY UNION is your most dependable joint. Write for Bulletin 700.

Pipe Sizes: ¼" through 5"



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PERFECTING SERVICE COMPANY, 332 Atando Ave., Charlotte, N.C.
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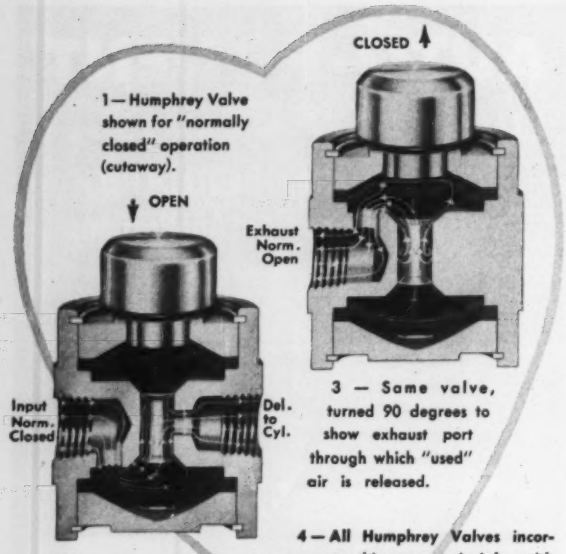

3 — Same valve, turned 90 degrees to show exhaust port through which "used" air is released.

2—In "open" position—(palm button depressed) air flows freely through wide ports into cylinder.

4—All Humphrey Valves incorporate this same principle—with choice of valve body styles for:
- Exterior mounting
- Insert for manifold
- Manifold-mounted

HUMPHREY "Quick-Dump" VALVES

OFFER MORE ON 2, 3, 4-WAY APPLICATIONS

- Pressures to 125 psi
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- Dead Seal Shut-Off
- High Capacity Porting
- Cycling to 30,000/Hr.
- Extra Service Life
- **For Original Equipment and Plant Use**

ELECTRICALLY OPERATED

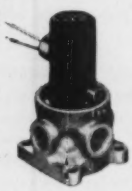
2-way and 3-way valves. Both one-coil "fail safe" and two-coil "momentary impulse" types.

MANUALLY OPERATED

2-way and 3-way finger-tip operation. A touch opens or closes. Many models — lever, cam, foot pedal, palm button, etc.

PILOT-OPERATED ELECTRIC VALVES

2-way and 3-way models, actuated by independent source of pressure. Two types: "fail safe" and "momentary impulse."



PILOT OPERATED VALVES

4-way 5-port shown (2, 3-way avail.) actuated by medium (gas or liquid) separate from medium being valved.

FULL ⅛", ¼", ½" CAPACITY THROUGHOUT—42 MODELS

Basically simpler, faster-operating, longer-lived control valves. For temperatures from —65 to 225° F. Many exclusive, better features for superior performance. Adopted by nationally known O.E.M. firms.

Engineering assistance available on valving problems.

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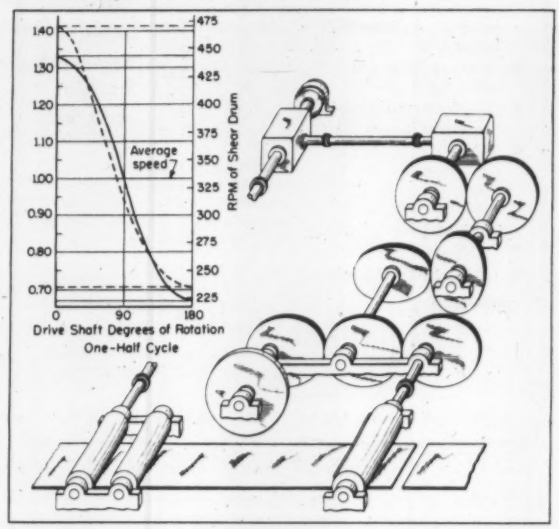
Pneumatic-Hydraulic Valves and Devices

which has no short turns. The path may be several revolutions long if it is helical. Under fluid pressure, the tube fills out the shell except at positions in which the traveler pinches the tube closed. A pin, which projects from the traveler through a slot in the rigid shell, is an attaching means for driven mechanisms. *Patent* 2,864,341 *assigned to General Precision Laboratory by Warren D. Novak.*

Dual Output Drive



A single motor drives a power transmission system from which outputs are constant speed on one shaft and cyclicly varying speed on a second shaft. Mechanical transmission from a single motor, instead of two, assures positive synchronization of the two outputs. The system includes elliptical gears—two center-rotated and three focus-rotated—so combined that the speed of the constant-speed output shaft is the average of the output cyclic speeds. The system is dynamically balanced by a flywheel designed to compensate cyclic output-torque action. *Patent* 2,861,635 *assigned to U. S. Steel Corp. by Howard S. Orr.*

Ultrahigh-Speed, Drive Belt

Saw-tooth section shape enables an endless belt to function without cleaning and without slipping from smooth pulleys at spindle speeds of 70,000 to 100,000 rpm. At these speeds, smooth belts build up an air cushion which causes them to slip off pulleys. The saw-tooth type passes this air out its sides. The teeth are formed in resilient material which allows them to deflect as they pass over pulleys. This action wipes oil and dirt from the pulley, promoting friction contact. *Patent* 2,865,214 *assigned to The Russell Mfg. Co., Middletown, Conn., by Leslie A. Runton.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

* Leather · Asbestos · Nylon · Vinyl · Teflon · Silicone Rubber · Neoprene · Rubber Cork · Fibre · Compositions · Phenolics · Cloth · Felt · Paper · Cardboard · Plastics Brass · Steel · Copper · Aluminum · Kel-F · Vitron A · Mylar · Other Special Materials

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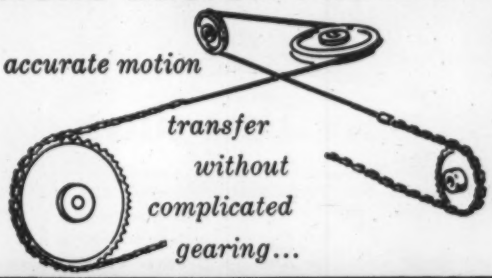
MORE DESIGN FREEDOM



SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

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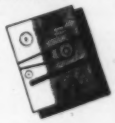

Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

123 E. Montecito Avenue, Sierra Madre, California

Sierra ENGINEERING CO.

T. M. REG.

Circle 535 on Page 19

Proven
ABSOLUTE PRESSURE CONTROLS

J20

by UNITED ELECTRIC

The Type J20 Absolute Pressure Control with its spring loaded, completely evacuated bellows provides positive switching . . . in response to source pressure variations . . . independent of atmospheric pressures and temperatures.

Pressure Range	0 to 35 psia
Adjustable Range	5.0 psia
Adjustments	factory calibrated at mid-point of the 5.0 psia adjustable range specified
Differential	factory set anywhere within limits of 1.5 to 5.0 psia
Repeat Accuracy	0.1 psia between −65° F to 160° F, altitude to 60,000 feet, 100% relative humidity
Switch Ratings	4 amps with non-inductive load of 28 volts D.C. or 10 amps at 115 volts A.C.
Switch Types	single-pole, single-throw, snap-acting class R—NC—opens on decreasing pressures class G—NO—closes on decreasing pressures
Electrical Connections	solder terminals on face of control can be pivoted and soldered in any position
Mounting	⅛" NPT, male thread to pressure source
Weight	approx. 5 ounces
Size	$3\frac{5}{32}$" x $2\frac{11}{32}$" x $1\frac{3}{32}$"
Applications	pressuring pumps on air-borne, mobile, or other equipment also in pressurized coaxial cables, in ground radar, and in maintaining frequency bands

UNITED ELECTRIC *also manufactures a complete line of temperature and pressure and vacuum controls . . . to exacting specifications . . . for innumerable applications. Special controls, modifications or custom-built, are available . . . consult a UE application engineer today.*

Write for J20 Bulletin today.

United Electric Controls COMPANY

85 SCHOOL STREET WATERTOWN MASS

Circle 536 on Page 19

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BEVEL GEARS

Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

We can make bevel gears up to 3" in diameter with up to 16 diametral pitch for such products as instruments, power tools, differentials, appliances, and fishing reels. Process bevel gears are precision engineered, deliveries are prompt.

Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.

#08

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Circle 537 on Page 19

MAYLINE

A Choice of Tops and Filing Units

Mayline steel base 4-post drafting tables are available with tops of solid basswood or steel covered with jaspe green linoleum. Top lengths range from 48" thru 84". All Mayline drawers ride on muted ball bearing rollers.

Mayline metal plan file drawers hold papers 24" x 36", 30" x 42", and 36" x 48" respectively. Provisions are also made for dividers to contain smaller size sheets.

Tables are described in folder S-21 and plan files in folder S-20. Inquire of your dealer or write to factory.

MAYLINE CO., INC.

601 No. Commerce Street

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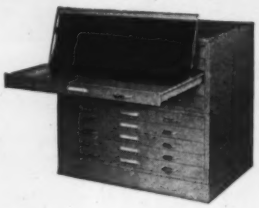

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- For inside and outside application. All sizes. Immediate delivery.

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PLASTIC tapered caps and plugs

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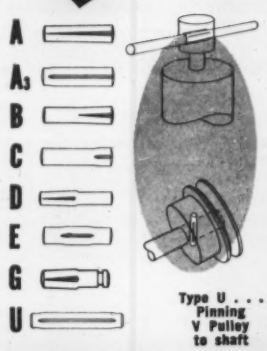

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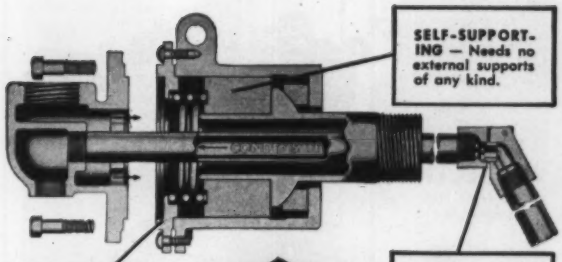
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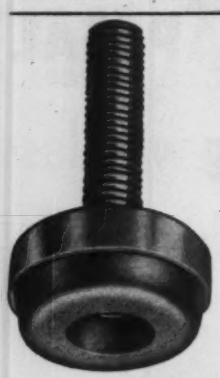

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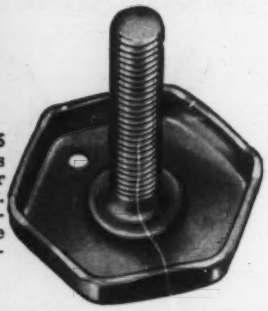

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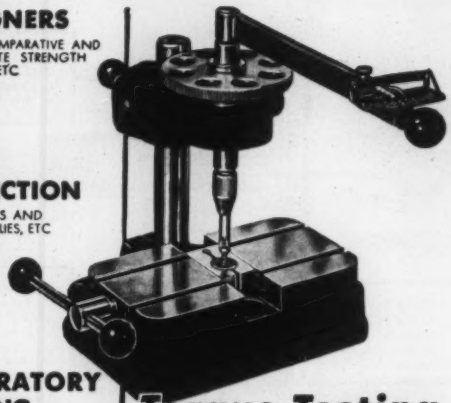

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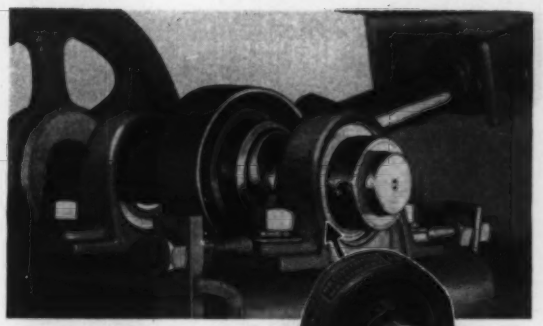

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Browning POWER TRANSMISSION EQUIPMENT

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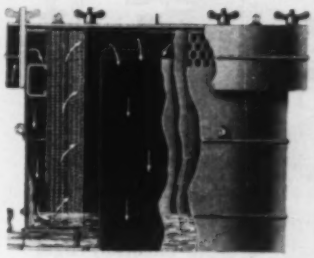
OIL BATH AIR FILTER

for engines, compressors and blowers



The Air-Maze Type F filter provides efficient removal of fine dirt from intake air to reduce wear on engine, compressor or blower parts.

High dirt removal efficiency is attained through its thorough scrubbing action. This scrubbing action is created by directing dirt-laden air into intimate contact with an oil pool. A "manometer" action created by the air passing a continuous baffle within the pool, causes more oil to be re-cycled than on other types of filter designs. Any dirt that remains in the air is then impinged on metal baffles. The metal baffles are kept clean by constant wash of the oil bath.

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Available in sizes from 20 to 6650 cfm. Write Air-Maze Corporation, Cleveland 28, Ohio. Dept. **MD-2.**

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Rae M-12 or M-13 with G-12 reducer. M-12 and M-13 motors AC/DC Universal or Shunt. 1/5 H. P. Max. G-12 gear unit 536:1 Max. and 100 in. lbs. Max. M-13 has ball bearings.

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NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds
UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC
ADJUSTABLE . . . time delays from .030 to 120 seconds
CHOICE OF OPERATION . . . for either energizing or de-energizing
SMALL . . . height—4 5/8" . . . width—1 13/16" . . . depth—1½"
LIGHT . . . maximum weight—15 ounces
MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

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1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

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Wilbow

Molded Rubber means Reliability

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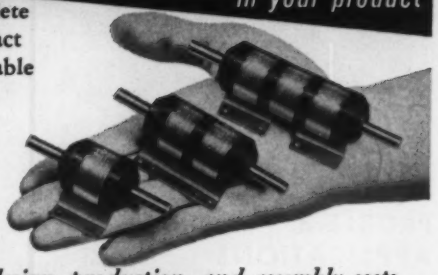

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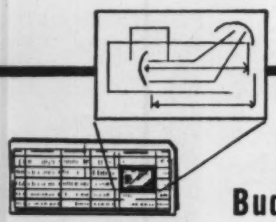

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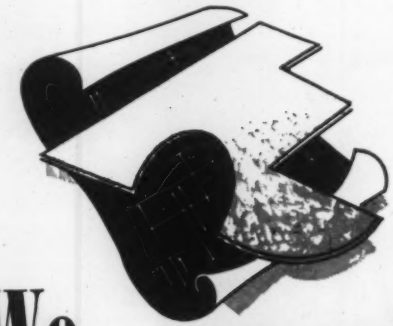

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. . . OPERATE on fundamentally new principle,—virtually no friction problems—permits predictable sensing of speeds to ¼ of 1%.

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electric clutch-brake for automatic positioning

simplifies machine control

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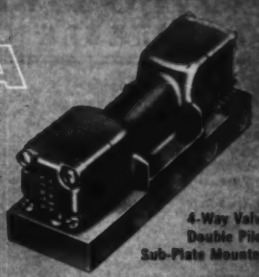

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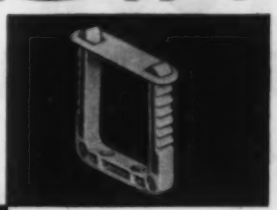

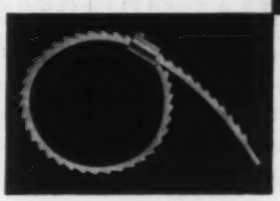

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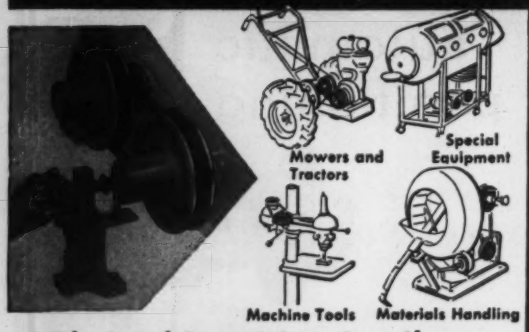
Control Speeds on Variety of Machines



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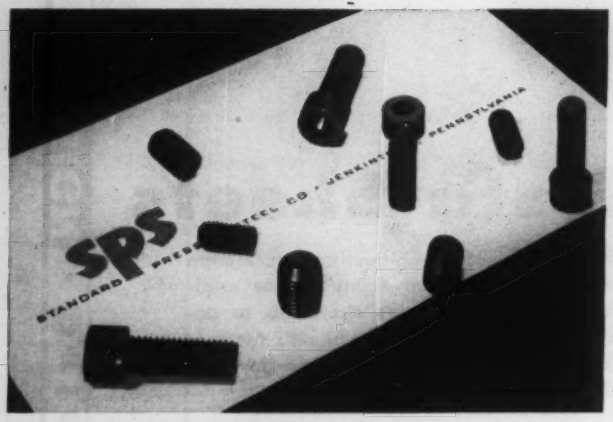

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#0	A .096		80	1/8		2.0	.21
	B .060		80	3/16		2.0	.22
	D .060		80	1/4		2.0	.26
	F .050		80	3/8		2.0	.33
#1	A .118		72	1/8		3.5	.31
	B .073		72	3/16		3.5	.36
	D .073		72	1/4		3.5	.42
	F .050		72	3/8		3.5	.53
#2	A .140	56		3/16	6.0		.54
	B .086	56		1/4	6.0		.61
	D .086	56		3/8	6.0		.76
	F 1/16	56		1/2	6.0		.91
#3	A .161	48		3/16	8.5		.77
	B .099	48		1/4	8.5		.87
	D .099	48		3/8	8.5		1.07
	F 1/4	48		1/2	8.5		1.27

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#0			80	1/16		.5	.03
			80	3/32		.5	.04
	D .060		80	1/8		.5	.05
	F .028		80	5/32		.5	.06
			80	3/16		.5	.08
			80	1/4		.5	.11
#1			72	1/16		1.5	.04
			72	3/32		1.5	.06
	D .073		72	1/8		1.5	.08
	F .035		72	5/32		1.5	.11
			72	3/16		1.5	.13
			72	1/4		1.5	.19
#2		56		1/16	1.5		.05
		56		3/32	1.5		.07
	D .086	56		1/8	1.5		.107
	F .035	56		5/32	1.5		.15
		56		3/16	1.5		.19
		56		1/4	1.5		.273
#3		48		3/32	5.0		.10
		48		1/8	5.0		.135
	D .099	48		5/32	5.0		.18
	F .050	48		3/16	5.0		.235
		48		1/4	5.0		.32

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Circle 560 on Page 19

Six of nine Cleveland Worm Gear Drives in use on the Anvil Lift Drive of this Mesta Gag Press are in view.

Gag press uses 9 CLEVELAND drives to straighten steel

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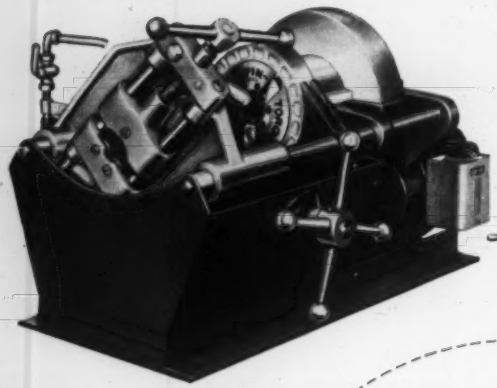
CLEVELAND
Worm Gear
Speed Reducers

Circle 402 on Page 19

The Toledo Pipe Threading Machine Company's compact No. 999 pipe and bolt machine features instant change from cutting to threading, quick-change die heads. Cutler-Hammer Motor Control is supplied as original equipment.



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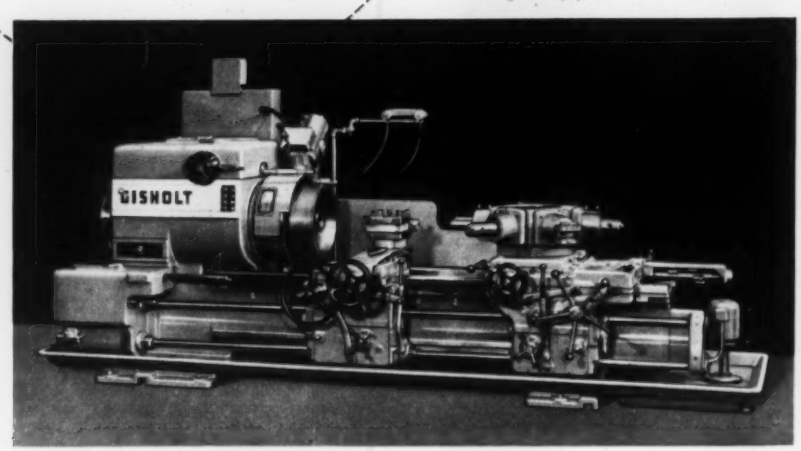

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